YEARBOOK

OF THE

UNITED STATES

DEPARTMENT OF AGRICULTURE.

1895

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MAIN BUILDING OF THE U. S. DEPARTMENT OF AGRICULTURE.

[PUBLIC—No. 15.]

An act providing for the public printing and binding and the distribution of public documents.

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Section 17, páragraph 2:

The Annual Report of the Secretary of Agriculture shall hereafter be submitted and printed in two parts, as follows: Part one, which shall contain purely business and executive matter which it is necessary for the Secretary to submit to the President and Congress; part two, which shall contain such reports from the different bureaus and divisions, and such papers prepared by their special agents, accompanied by suitable illustrations, as shall, in the opinion of the Secretary, be specially suited to interest and instruct the farmers of the country, and to include a general report of the operations of the Department for their information. There shall be printed of part one, one thousand copies for the Senate, two thousand copies for the House, and three thousand copies for the Department of Agriculture; and of part two, one hundred and ten thousand copies for the use of the Senate, three hundred and sixty thousand copies for the use of the House of Representatives, and thirty thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture; and the title of each of the said parts shall be such as to show that such part is complete in itself.

PREFACE.

Ever since 1849, when the report of the Department of Agriculture was first published in a separate volume, as Part II of the Annual Report of the Commissioner of Patents, it has been customary to issue large editions for distribution by Congress. Of the report for 1851, 110,000 copies were printed, 100,000 of which were for distribution by Congress. The original edition of 110,000 copies was gradually increased with the growth of the population of the country and the development of its various agricultural interests, until it reached in 1892 half a million copies. The volume in the old form was made up of business and executive reports for the use of the President and of Congress, and such statements of the results of scientific work as promised to be useful to farmers. In the belief that a volume designed for such extensive distribution among farmers should be specially prepared for them, a provision was incorporated in the act of January 12, 1895 (printed on the opposite page), requiring that future annual reports of the Department of Agriculture should be divided into two volumes: First, an executive and business report, and, second, a volume made up of papers from the Department bureaus and divisions "specially suited to interest and instruct the farmers of the country." As the report for 1894 had been prepared before this act became a law, all that could be done last year was to separate the papers submitted and publish them in the new form. While it is hoped that the present volume is somewhat of an advance upon the Yearbook for 1894, it does not fully come up to the ideal which the Department has set before it.

The plan has been to prepare a volume consisting of three parts:

(1) "A general report of the operations of the Department" during the year, by the Secretary of Agriculture.

(2) A series of papers from the different bureaus and divisions of the Department, and from some of the experts of the agricultural experiment stations, discussing in a popular manner the results of investigations in agricultural science or new developments in farm practice. These papers are presented in the form of popular essays rather than scientific reports, and with the object of making them attractive as well as instructive they are illustrated as fully as possible. The several topics have been treated in as thorough a manner

as space permitted, but no attempt has been made to cover the entire range of subjects that would be included in a handbook of agricultural science. As the years go on, it is hoped that the Department will, in successive issues of this work, give farmers a good library covering the applications of science to practical agriculture. No systematic treatment has, however, been possible in planning for this or succeeding Yearbooks, and only such subjects have been taken up as have been reasonably well investigated and seem timely or suitable for discussion.

(3) An appendix. The publications of the United States Government having more or less bearing upon agriculture have become so numerous that an epitome of their more important contents has become almost a necessity. Scattered through the publications of the Department of Agriculture, for example, are many valuable data, facts of interest, recipes, and directions with regard to agricultural and horticultural practice, which it is desirable to bring together for convenience of reference. Accordingly, in the appendix to the present volume there will be found a large amount of miscellaneous information taken from the reports of this Department and presented with especial regard to the requirements of the agricultural reader. Statistics of agriculture taken from the reports of the Census, and much interesting information relative to the exports, imports, and per capita consumption of agricultural products from the publications of the Bureau of Statistics of the Treasury Department, have also been compiled in convenient form down to the latest available date.

It has thus been sought to make the volume a concise reference book of useful agricultural information based in great part upon the work of this and other Departments of the Government, without making it an encyclopedia of general information. In brief, the effort has been to make a book, and not a mere Government report—a book worthy to be published in an edition of half a million copies and at an expense to the people, if we count both publication and distribution, of over $400,000.

Time and space have not been spared in the preparation of an index to the book, which, it is believed, will prove an efficient guide to all who consult it.

CHARLES W. DABNEY, Jr.,
Assistant Secretary.

WASHINGTON, D. C., *February 1, 1896.*

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YEARBOOK

OF THE

U. S. DEPARTMENT OF AGRICULTURE.

REPORT OF THE SECRETARY.

Mr. PRESIDENT:

The Secretary of Agriculture has the honor to submit his Third Annual Report. It is a statement of the doings of the United States Department of Agriculture during the fiscal year ended June 30, 1895. It will show wherein expenditures have been reduced for the sake of economy, and wherein they have been increased for the sake of efficiency.

BUREAU OF ANIMAL INDUSTRY.

MEAT INSPECTION.

Meat inspection during the fiscal year increased and improved. The public demanded more extended and critical inspection in all the great cities where the larger abattoirs are located. Earnest efforts were made by the Department to inspect all animals slaughtered for interstate and foreign trade. Those efforts, however, have been made only in the cities where United States inspection has been permanently instituted. At such killing places calves and sheep have been included in the inspection.

The number of animals inspected at slaughterhouses during the year was 18,575,969. During the preceding year only 12,944,056 were inspected. This shows 5,631,913 more this year than last. The work, therefore, of inspection at the abattoirs during the fiscal year ended June 30, 1895, was augmented by about 43 per cent. During the same year, in the stock yards, ante-mortem inspection was also made of 5,102,721 animals.

By order of the President of the United States, inspectors were placed in the classified service on July 1, 1894. Since that time the number of those officers has been largely reenforced from the list of eligibles recorded in the office of the United States Civil Service Commission. All inspectors thus appointed are graduates of reputable

veterinary colleges and have passed satisfactory examinations in veterinary science before the Civil Service Commission. Therefore the educational acquirements of the corps of inspectors are of so high a grade that meat and animal inspection must become of great sanitary value to consumers at home and to interstate and foreign commerce, provided State and municipal authorities intelligently and diligently cooperate with those of the National Government. If such cooperation fails, then the people of the great killing centers become the consumers of all rejected animals and meats. The protection of domestic health will be much improved when each purchaser of meats demands and insists upon that which has been governmentally inspected and certificated.

Had not the whole matter of animal and meat inspection better be relegated to State and municipal authority? When and where will the duties of the Bureau of Animal Industry otherwise be defined and restricted? And what will be ultimately the annual appropriation of money required to compensate its constantly increasing force of inspectors, assistant inspectors, stock examiners, and taggers?

But whether inspected by national or State authorities, the owners of the animals and carcasses inspected should pay for the service which confers an added selling value to their commodities.

During the year this inspection cost 1.1 cents per animal inspected. The aggregate sum paid out for that service was $262,731.34.

In 1893 inspection cost 4¾ cents per animal. In 1894 it cost 1¾ cents per animal.

This service has been maintained during the year at 55 abattoirs, situated in 18 cities. During the previous year inspection was conducted at only 46 abattoirs and in 17 cities.

MICROSCOPIC INSPECTION OF PORK.

During the fiscal year 1895, 45,094,598 pounds of pork were examined microscopically and exported, while during the year 1894 only 35,437,937 pounds went abroad, and in 1893 only 20,677,410 pounds of microscopically examined pork were exported.

And notwithstanding the agrarian protectionists of Germany, who have instituted by unjust discriminations every possible impediment to the consumption of pork and beef from the United States in that Empire, 29,670,410 pounds of microscopically inspected hams, bacon, and other cured swine flesh were exported directly to that country; while France, which is intermittently discriminating against us, took 9,203,995 pounds of the same product; Denmark, 472,443; Spain, 4,752; and Italy, 3,630. Indirectly Germany and France probably received much more American bacon and hams than can be estimated from data at hand; but the amounts set down for those two countries were sent directly to German and French ports, and can be verified by the records of the Department of Agriculture.

Reciprocal certification of the chemical purity of wines exported from those countries to the United States may some time be demanded from the German and French Governments as a sanitary shield to American consumers, for certainly American meats are as wholesome as foreign wines.

In the fiscal year 1895, 905,050 hog carcasses and 1,005,365 pieces of swine flesh were microscopically examined. This shows a total of 1,910,415 specimens placed under the microscope. The cost of this was $93,451.10. The cost of each examination was therefore 4.9 cents. In 1893 the same examination cost $8\frac{3}{4}$ cents per specimen, and in 1894, $6\frac{5}{6}$ cents.

The foregoing statement shows a reduction of 25 per cent in the cost of inspection in 1894, compared with the inspection in 1893; it shows likewise a reduction of 25 per cent in 1895, compared with 1894. This inspection cost for each pound of meat in 1894, $2\frac{48}{100}$ mills, and in 1895 it cost 2 mills per pound.

INSPECTION OF LIVE ANIMALS FOR EXPORTATION.

During the year 657,756 cattle were inspected for the export trade, and in 1894, 725,243.

The United States actually exported during the fiscal year 1895 324,299 head, but in 1894 they sent out 363,535. This shows a falling off of exported cattle during the fiscal year 1895 of 39,236 head, compared with the year 1894.

Out of all the cattle inspected, 1,060 were rejected during the year 1895, while only 184 were rejected during the year 1894.

The number of sheep inspected for exportation in 1895 was 704,044. The number really exported was 350,808. In 1894 only 85,809 were sent abroad. Therefore, there was in the year 1895 an increase of 264,999 exported sheep. This increase is over 300 per cent.

The foregoing statement shows that, taking cattle and sheep together, 1,361,800 animals were inspected in the year for foreign markets. It also shows that out of that number a total of 675,107 animals were shipped abroad.

Every bovine animal was tagged and numbered. Each number was registered so that individual animals could be identified. All the cattle were certified to be free from disease.

DANGERS AND DIFFICULTIES OF SHEEP SHIPMENTS.

Sheep, although healthy when exported, sometimes become affected with scab while on shipboard. Large numbers of sheep crowded together in a vitiated atmosphere are conducive to the speedy development of scab. In case any of the parasites of that disease are present the symptoms of scab are rapidly developed during the voyage. Flocks carefully examined and found entirely free from any symptoms of disease at the time of embarkation are sometimes found

badly affected with scab when landed. Prolonged and diligent study has been given to provide measures to prevent infection with this disease. It is probable that some of the sheep are infected in cars which have previously carried diseased animals. Others are infected in stock yards, while others may be infected in the ships themselves. It is evident that to guard against all these sources of infection comprehensive regulations are required for the disinfection of cars, stock yards, and ships, and, furthermore, that inspection must be so rigorous and specific as to prevent the sale by growers and feeders of diseased sheep to be placed on the market.

VESSEL INSPECTION.

All vessels in the export cattle and sheep trade have during the year been thoroughly inspected by officers of the Bureau of Animal Industry. That inspection was made in accordance with the act of Congress approved March 3, 1891. Revised regulations have been issued embodying the amendments suggested by actual experience since that law came into vigor.

The losses of live animals exported from the United States during the year have been heavier than usual. An investigation has therefore been commenced to determine whether any part of these losses was due to noncompliance with the regulations of this Department. Great Britain found that out of the 294,331 head of American cattle shipped to England, a loss was incurred while in transit of 1,836 head; that is, 0.62 per cent, as compared with 0.37 per cent in 1894.

The number of sheep inspected after landing in Europe was 310,138. There had been lost in transit 8,480 head—that is, 2.66 per cent—in 1895. In 1894 the loss was 1.29 per cent.

STOCK YARDS INSPECTION.

Stock yards inspection is to prevent the spread of contagious diseases through interstate and foreign commerce. Texas fever is the only disease thus far absolutely controlled by this inspection. The further development and improvement of its active force in the field will enable the Bureau to finally include hog cholera, tuberculosis, sheep scab, and other diseases in its examinations of domestic animals in market.

QUARANTINE SEASON AGAINST TEXAS FEVER.

From February 15 to December 1, 1894, there were received from the infected cattle districts and inspected at quarantine pens 30,531 cars of cattle. Those cars carried 826,098 animals.

During the same period 8,958 carloads of cattle were inspected in transit, and 28,650 cars were cleaned and disinfected under the supervision of inspectors. During the same time there were also inspected 156,660 cattle from the noninfected district of Texas, which had been

shipped or driven to Northern States for feeding purposes. The identification of the branding of all those cattle was necessary. That determined whether they could be with safety grazed and fed in the North.

COST OF TEXAS FEVER AND EXPORT INSPECTION.

Inspection to guard against Texas fever in interstate and foreign trade cost $104,492.46. Assuming that half of that sum should be charged to the inspection of export animals, the cost of inspecting 675,107 head of animals (cattle and sheep) exported would be $52,246.23, just 7.74 cents per head. During the preceding year the per capita cost, computed in the same way, was 10.75 cents. The number of individual animals inspected in this country was 1,361,800, and 604,469 were inspected in Great Britain. This makes a total of 1,966,269 animals. Thus the average cost of one inspection for each individual animal was 2.66 cents.

INSPECTION AND QUARANTINE OF ANIMALS IMPORTED INTO THE UNITED STATES.

During the year the United States imported, quarantined, and inspected at the Garfield Station, in New Jersey, 142 head of cattle, 23 swine, and 3 moose, besides 9 cattle from India; at Littleton, near Boston, Mass., 12 sheep were quarantined and inspected; at Buffalo, N. Y., 366 cattle, and at Port Huron, Mich., 1 bovine. Altogether 702 imported animals from Europe were quarantined for the prescribed period and inspected.

ANIMALS FROM CANADA.

During the same period 293,594 animals were imported from Canada, but not subject to quarantine, as follows: 292,613 sheep, 908 swine, 48 head of cattle, and 5 moose.

CATTLE FROM MEXICO.

From January 1, 1895, to June 30, 1895, 63,716 head of inspected cattle came into the United States from the adjacent Republic of Mexico. All of that number of animals were critically examined and passed upon by the employees of the Bureau of Animal Industry. No diseases were found among them. Their sanitary condition was, as a rule, most excellent, and their weights showed an improvement in breeding, while some animals were of very high grades.

It is suggested that if the duty were taken off Mexican cattle it would be of great advantage to the grazers of Texas and the feeders of Kansas, Nebraska, and other Northwestern States which have a surplus of corn to convert into beef. Should these cattle be let in free of duty, it would certainly not enhance the price of steaks and roasts to beef eaters in the United States, who largely outnumber beef producers.

SCIENTIFIC WORK OF THE BUREAU.

Researches by the scientists of the Bureau, directed by Dr. D. E. Salmon, its chief, have during the past year yielded satisfactory and valuable results. Investigations are now in progress, the objective points of which have not yet been attained, though there is reasonable ground to believe that conclusions may be reached which will prove of great value to the growers and feeders of domestic animals throughout the United States. For specific descriptions of the investigations here alluded to reference is respectfully and confidently made to the Report of the Chief of the Bureau of Animal Industry, which will record in detail the attempts to destroy Texas fever ticks upon and among Southern cattle by various insecticides. That report will disclose the amount of tuberculin and mallein sent out, upon application, to the proper authorities of the several States of the Union during the fiscal year.

DAIRY DIVISION.

The dairy division was organized July 1, 1895, with Major H. E. Alvord as chief, with an assistant chief and two clerks. Its work for some time to come will be largely confined to the collection and dissemination of information relative to dairying as carried on in the United States and some foreign countries. Original scientific research bearing upon this branch of rural industry will necessarily be postponed until proper foundations have been laid therefor out of the experiences and observations that at present are being collected. It is hoped that this division will prove of great educational advantage to the farmers of the country. It is not reasonable to expect from the division anything more than practical didactics. It is not the province of this division, or any other in the United States Department of Agriculture, to do more than plainly instruct people in the various branches of farming how to intelligently help themselves.

During the fiscal year the Bureau of Animal Industry issued many reports, bulletins, and circulars which have been in great demand among the editors of agricultural periodicals and the intelligent farmers of the United States.

The appropriation for the Bureau for the year ended June 30, 1895, was $800,000. Out of that sum less than $533,000 has been expended. The balance to be returned to the Treasury of the United States will, when the year's accounts are finally closed, exceed $250,000.

FOREIGN MARKETS FOR AMERICAN MEAT PRODUCTS.

Cheap swine feed throughout the Kingdom of Great Britain during the past year caused a large increase there in home-fattened pork. The British farmer, even at the present low price of bacon, finds it more profitable to fatten hogs than to market beans, pease, and cereals. The number of breeding sows in Great Britain increased over 100,000

during the year. That was an advance of more than 64 per cent. The number of other swine increased 430,314. This was an advance of more than 21 per cent. The total number of swine in Great Britain on the 4th day of June, 1895, is officially stated at 2,884,431.

The British swine-flesh increase helped materially to depress the market for imported meats. Therefore prices averaged considerably lower during the year 1895 than in the year 1894. But the September prices of the year 1895 were not lower than those of the previous year. The Wiltshire packers, at Calne, England, are paying 9½ cents per pound for hogs on foot not exceeding 150 pounds in weight and not carrying more than 2½ inches of fat on the back. Heavier weight hogs bring smaller prices. English packers invariably pay a premium for swine precisely adapted to making the kind of bacon most in demand—that is to say, lean, thin, and mildly cured. The call for this sort of meat throughout Great Britain has caused a change in the breeding of swine throughout almost the entire realm. The Tamworth hog is now in more request than the Berkshire, Essex, or any other established breed. The farmers and packers of the United States must *study and cater to foreign desire and demand in this* respect if they propose to secure and hold at a profit their share of the foreign markets.

During the past summer there was a very considerable advance in the price of the bacon offered in the English market from Canada, from the Continent, and from the English abattoirs. This rise was brought about by a temporary shortness of bacon supplies, but United States bacon did not participate to any appreciable extent in the general advance, for the reason that as prices went up consumption was checked and imports were increased, so that there came to prices a speedy decline. Competition in supplying bacon to European markets is increasing from year to year because of the increasing number of packing houses upon the Continent. Danish bacon is constantly growing in favor with the European consumers. The shipments of that meat from Denmark during the seven months ended July 31 last were increased 9,049,600 pounds, compared with the shipments for the parallel period of the year 1894, notwithstanding the Danes received, because of a low-priced market, less money for the increased quantity by nearly $250,000 than the previous year yielded.

The shipments of United States bacon increased in that time 15,680,000 pounds. But it brought less money by $1,000,000 than the shipments of the year 1894. During the same time Canada received a less sum of money for an increased exportation of bacon to Europe.

Modern methods of skillfully preparing and preserving great varieties of meat and vegetable foods of all kinds keep European and all other markets almost constantly supplied with a great variety of palatable and wholesome edibles. Moreover, the rapidity with which the United States and parts of Europe can respond to any unusual

demand for bacon and other pork products renders it improbable that there will be any considerable and permanent advance in the prices of hog products during the immediate future. But if there should come an advance, it will, it is reasonable to conclude, be maintained only temporarily. American packers can only obtain and hold English and other European bacon markets by specially preparing their meats to meet the taste and demand of those markets. Smaller and leaner swine for bacon purposes are demanded in nearly all foreign markets. And the meat must be mildly cured. But in Mexico and some of the South and Central American States the heaviest, fattest, and thickest sides are required.

The American packers who will cure bacon as above described for European consumption and maintain a high quality for their brands will find a reward not only in European but in the home markets, for it is a fact that each year limited quantities of English bacon are shipped uninspected to New York and Boston grocers, who retail it at high figures to fastidious customers. It is considered a luxury at some American breakfast tables, though no inspection has been demanded or imposed by the United States.

The following tables will be of interest to American producers and consumers alike:

Wholesale prices of bacon and hams in London.

BACON.

[Per 100 pounds.]

Product.	September, 1895.	Same time last year.	July, 1895.	Same time last year.
Irish	$12.85-$13.50	$13.00-$13.40	$9.75-$12.37	$13.03-$15.20
English	*14.09 15.10*	*14.00 17.00*	*10.42 11.72*	*14.11 16.29*
Continental	9.69 14.11	10.85 13.25	9.33 11.72	12.00 14.77
American (middles, short ribs)	8.25 8.68	9.54 10.50	7.37 7.81	8.68 9.54
Cumberland cut	9.11 9.54	9.54 9.98	7.37 7.81	8.25 9.98
Singed sides	9.54 9.98	9.11 9.98	6.94 7.37	9.54 9.98
Canadian	10.50 11.28	10.00 11.28	9.11 9.98	10.85 11.71
Legs, green	9.11 11.71	12.50 13.00	10.64 12.25	12.58 13.09

HAMS.

Product.	September, 1895.	Same time last year.	July, 1895.	Same time last year.
Irish	$17.33-$22.00	$15.70-$21.50	$15.64-$20.41	$16.53-$21.28
Cumberland	17.33 19.50	18.00 21.75	17.33 21.73	17.78 21.73
American:				
Long cut	9.54 10.25	11.60 12.60	......	......
Short cut	8.68 10.25	11.50 12.40	......	......

Imports of bacon into the United Kingdom during the first seven months of 1895, with comparisons with a similar period in each of the two previous years.

From—	Quantities[1] for seven months ended July 31—			Values for seven months ended July 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Denmark	400,491	474,335	555,179	$5,905,405.28	$6,737,489.18	$6,505,206.26
Germany	8,595	211	15	127,307.64	3,031.82	187.79
Canada	39,374	85,413	86,607	513,493.60	854,275.14	775,267.51
United States	1,211,448	1,539,628	1,681,340	14,933,090.70	14,931,940.34	13,924,204.98
Other countries	59,242	50,890	73,422	760,580.41	657,483.61	904,521.75
Total	1,719,150	2,150,477	2,396,563	22,239,877.63	23,184,220.09	22,109,390.29

[1] In hundredweights of 112 pounds.

Imports of hams into the United Kingdom during the first seven months of 1895, with comparisons with a similar period in each of the two previous years.

From—	Quantities[1] for seven months ended July 31—			Values for seven months ended July 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Canada	16,822	19,150	35,987	$260,766.03	$231,324.18	$388,117.97
United States	510,460	629,701	764,376	7,564,365.93	7,378,397.50	8,238,478.37
Other countries	6,402	2,534	2,103	99,373.93	41,204.65	32,006.97
Total	533,684	651,385	802,466	7,924,505.89	7,650,926.33	8,658,603.31

[1] In hundredweights of 112 pounds.

Imports of pork into the United Kingdom during the first seven months of 1895, with comparisons with a similar period in each of the two previous years.

Product.	Quantities[1] for seven months ended July 31—			Values for seven months ended July 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Salted (not hams):						
From United States	56,295	84,675	82,034	$514,841.63	$700,099.55	$564,927.64
From other countries	41,131	44,663	47,366	242,064.57	302,175.58	262,124.28
Total	97,326	129,341	129,400	756,906.20	1,002,275.13	827,051.92
Fresh:						
From Holland	60,251	51,905	114,179	696,347.48	591,221.35	1,268,526.21
From Belgium	14,613	15,240	14,419	176,454.42	186,284.75	173,476.12
From other countries	19,078	14,921	8,513	257,423.24	198,013.01	74,681.30
Total	93,942	82,066	137,111	1,130,225.14	975,519.11	1,516,683.63

[1] In hundredweights of 112 pounds.

Imports of lard into the United Kingdom during the first seven months of 1895, with comparisons with a similar period in each of the two previous years.

From—	Quantities[1] for seven months ended July 31—			Values for seven months ended July 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
United States	631,884	834,028	1,067,646	$8,072,954.11	$8,068,525.60	$9,040,550.57
Other countries	21,658	11,622	10,476	282,359.19	113,540.29	97,334.86
Total	653,542	845,650	1,078,122	8,355,313.30	8,182,065.89	9,137,885.43

[1] In hundredweights of 112 pounds.

Wholesale prices of lard in London.

[Per 100 pounds.]

Product.	September, 1895.	Same time last year.	July, 1895.	Same time last year.
Irish:				
Bladders	$8.68–$10.85	$10.85–$12.79	$7.81–$11.07	$10.42–$12.25
Kegs	8.00 8.50	9.50 10.25	7.81 8.25	8.90 9.54
English	10.25 10.85	11.75 12.25	9.98 10.42	11.07 12.00
Continental	7.70 8.68	11.28 11.50	8.25 9.11	10.85 11.07
American pails	6.93 7.15	10.15 10.35	7.37 7.49	8.48 8.68
Compound, or lardine	5.63 5.85	7.60 8.48	5.96	6.08 6.56

CATTLE AND MEAT TRADE WITH GREAT BRITAIN.

In June, 1895, English farmers carried 4,500,000 head of cattle. Three years before the same farmers owned 5,000,000 head. Thus a decline of 10 per cent is shown in thirty-six months.

In Scotland, in June, 1895, there were 1,178,000 cattle; in Wales, 704,000, and at the same time Ireland contained 4,358,000. Thus the total for the United Kingdom, in June, 1895, is about 10,750,000 head. But the United Kingdom is not holding its proportion of the trade as a purveyor of meat to its own people. Up to the present year the United States and Canada have had an unquestioned monoply in the supply of imported live cattle to the British people; but now there is vigorous and growing competition from Argentina and also incipient competition from Australia.

The bulk of American shipments must be classed as first quality. The London average price for the six months ended August 31, 1895, for prime cattle was $8 per 100 pounds on foot; the Liverpool average, $7.43; the Newcastle average, $7.62; and the Edinburgh average, $7.59. It is, however, only when we are dealing with live weights—that is to say, when the cattle are passing wholesale into first hands on the other side of the Atlantic—that we are able to detect any considerable difference between quotations for American beef and those for English or Scotch beef. During the first six months of this year domestic beef sold in Liverpool by the carcass at from $8 to $11.50 per 100 pounds. During the same time beef from the United States sold by the carcass at from $10 to $10.75 per 100 pounds. The Liverpool prices include all grades of domestic cattle; but shipments from the United States are picked lots. Our prices did not, therefore, decline to within $2 of the Liverpool minimum, but the Liverpool maximum price exceeded ours by three-fourths of a cent per pound.

However, only a limited number of very fine carcasses were sold at top Liverpool prices, while a fair average of United States steers reached the maximum of $10.75 per 100 pounds. Therefore, American carcasses, sold in Liverpool, approximated the same prices that English, Irish, or Scotch brought in the same market. The fact that a

large number of Irish and some Scotch cattle are slaughtered at the Liverpool abattoirs, and that Liverpool's domestic trade is not subject to the same conditions which control the import trade from the United States, should not be lost sight of. To illustrate, prices at Birkenhead are sometimes considerably depressed by the simultaneous arrival of carcasses of cattle from Canada and the United States, while domestic prices at the Liverpool abattoirs are not thereby in the slightest degree affected.

During the nine months of the year ended with last September, at the great Central meat market in London, the prices of prime Scotch and English beef compared with the prices of American as follows: Scotch sides, $11.25 to $14.62½ per 100 pounds; English prime, $11.25 to $12.87½ per 100 pounds; American, $9 to $11.50 per 100 pounds. The extremely hot weather of September lowered all prices, and the high temperature of that month is wholly responsible for the minimum quotation of $9 per 100 pounds for American beef. Up to the beginning of September the lowest price during the year had been $10.50 per 100 pounds. Top prices in London are only paid for the finest beef of the world. But the minimum prices of that city do not by any means represent the poorest quality. That finds a more profitable market elsewhere. The top prices for American beef in London are, as a rule, about equal to the bottom prices for the best Scotch and English beef. When United States meat is selling from $10 to $11 per 100 pounds the Scotch and English are usually bringing from $11 to $14 per 100 pounds. Of course, these prices refer exclusively to the wholesale market and dealings. The apparent disparity in values disappears when the beef reaches the retailer.

A Birkenhead-killed American side reappears in the retail market as "prime Scotch," while a Deptford-killed United States steer masquerades as "prime English beef." The British consumer is unable to detect, either by eye or palate, the origin of a side of beef or the roast cut from it. Thus far all attempts to identify and establish the nativity and fattening places of meats in English markets have failed. British consumers learned long ago that they had been thoroughly and completely deceived by buying American for Scotch and English beef. The conclusion drawn from said successful and nutritious deception is that American beef is as good as any in the whole world. The complaint now made by consumers is merely that the retailer does not allow them to participate in the profits which he makes upon United States beef over and above those which he pockets upon Scotch and English of the same or similar quality.

The report of the London Central Market, just issued, states that of the 341,000 tons of meat received there in 1894, 71,638 tons were American (this includes the relatively small quantity shipped from Canada), and 49,908 tons came from Australia and New Zealand. The United States and Canada will not be able in 1895 to show that

they have supplied 20 per cent of the meat entering the great London market, and it may be a long time before they will repeat the figures of 1894. During the present year, however, steadier trade and prices have been quite satisfactory to American shippers and far more productive of profits than were the flurries and fluctuations of last year. Cattle in Great Britain from the United States represent more than 68 per cent of all its beef importations. During the year United States beef carcasses have exceeded in price those from Canada by 25 cents per 100 pounds.

Argentina during the first eight months of 1893 sent to Europe 5,643 head of cattle. During the same period of 1894, 7,831 head were exported, and during a corresponding period in 1895, 25,165 head. The shipments of this year were valued at $9,181,000. Thus they were priced on the other side of the Atlantic at $78.72 per head; that is, $6.71 less than the declared value per capita of cattle from the United States. But this difference in price inadequately represents the decided difference in quality. South American cattle are coarser than ours, and the meat is not so salable in the English market. Prices of Argentina beef per carcass range from $1 to $2.50 per 100 pounds less than those paid for North American cattle. There is, however, no doubt that the Argentina shipper can make a profitable business at the prices named, and from year to year shipments from that Republic will continue and increase. Argentina is the most formidable beef-selling competitor of the United States in the world's markets.

Australia made the first large shipment of live animals from the Antarctic continent on the steamship *Southern Cross*, 5,050 tons register, which arrived at London from Sydney on the 10th day of September, 1895, laden with cattle, sheep, and horses. This steamship came by way of Montevideo. That route was taken to avoid the heat of the Red Sea. The voyage occupied two months. During that time 52 cattle, 82 sheep, and 1 horse were lost. The shipment originally was made up of 550 cattle—grade Herefords and Durhams; 488 sheep, which were crossbreeds and Merino wethers, and 29 horses; the whole in charge of 30 men. The freight upon the cattle and horses was $39 a head, and the freight rate upon each sheep was $2.50. This Department is credibly informed that the freight, insurance, fodder, and attendance amounted to $68.25 for each horse and each beef animal, and to $6 for each head of sheep. The value of the cattle at Sydney was $20 a head; therefore they stood the shipper, upon arriving at Deptford, where they were sold, $88 apiece.

The condition of the animals was fair, as those which had been selected for the experiment were very large and coarse, the idea being that it cost no more to send a large steer than a small one. The prices realized were a great disappointment to the shippers and were entirely inadequate to recoup them. It is therefore generally admitted

in England that the experiment resulted in a very considerable loss. However, it is by no means certain that further experiments will not be made, nor can Americans congratulate themselves upon having no competition in the future from Australian cattle and their products in the markets of Europe. Frozen beef from that country will continue to be placed (although it is admitted to be of inferior quality) in European markets. But it is charged that out of the Australian cattle which arrived on the *Southern Cross* and were killed at Deptford 12 were found to have contagious pleuro-pneumonia.

Shipments of chilled beef from the United States fell off during the first eight months of the present year 11,000,000 pounds, but increased over the corresponding months of 1893 by about the same number of pounds. The high quality of beef shipped to Europe from the United States has been steadily maintained and appreciated by remunerative and profitable prices. Refrigerated hind quarters sold during the year from $10.50 to $13.50 per 100 pounds. The maximum price has been considerably above the top prices at any time obtainable for beef from American cattle killed upon landing at the abattoirs of either Deptford or Birkenhead. Naturally it seems that the shipments of chilled beef should rapidly increase and cause a decline and impairment of the live-cattle transatlantic trade. Nevertheless, it appears to work out more profitably to transport the live cattle. They are carried on parts of the ship that would otherwise be unoccupied. They do not require such special fittings and appliances as to debar the vessel from carrying other cargoes when cattle are not available.

Shipments of frozen beef from the antipodes may possibly become more common in English markets. But after it is defrosted it is unsightly in appearance, lacks flavor, and is repulsive when served in the English method as a "cold joint" the second day after cooking. Australian hind quarters have sold from $6.50 to $7 per 100 pounds throughout the present year, up to September 1, at the Central Market in London. That is only a trifle more than half the prices quoted for American refrigerated hind quarters.

AMERICAN CATTLE IN GLASGOW.

During the year ended May 31, 1895, there were only 26,426 cattle from the United States landed at Glasgow. From June, 1879, to the 31st day of May above mentioned, American cattle landed at Glasgow numbered 337,627 animals. As a rule the cattle arrived there in good condition. The authorities of Glasgow make no discriminations against American live stock when compared with that from Canada. Animals from both countries are, by law, slaughtered within a certain number of days after landing. The average prices realized in Glasgow for cattle from the United States have been about 1 cent less than those obtained for Scotch cattle. The latest sale held at Yorkhill, Glasgow, on September 30, 1895, was of 384 United States animals,

which realized, for 266 steers, from $62 to $85 and $115 each, and 32 bulls, which sold per head from $50 and $65 to $96.

Approximately the dead-weight quotations for the animals were: Best quality of steers, $12.15 per 100 pounds; heavy prime steers, $11.71; rough, secondary animals, $11; and at the same market, five days before—that is, on September 25—top Scotch cattle sold at $13 to $13.70 per 100 pounds; secondary, $12.37 to $12.80; third quality, $8.45 to $10.20; middling and inferior, $5.42 to $7.80. The bulk of the meat from American cattle sold at Glasgow is cut and retailed without any distinctive reference as to where it originated. In that city there are comparatively few retail dealers who sell Scotch beef exclusively. Those few retailers demand higher prices than those asked by dealers offering both Scotch and American meats. American cattle in the Scotch markets are looked upon as far superior in grade and quality to Irish cattle; in fact, they are regarded as next to the best Scotch.

The following tables explain themselves:

Table showing the quantity and value of beef imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

Product.	Quantities[1] for eight months ended August 31—			Values for eight months ended August 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Salted:						
From United States	122,327	150,260	135,381	$780,104.81	$1,085,837.81	$851,630.39
From other countries	6,284	5,701	3,355	54,134.93	38,265.28	24,244.90
Total	128,611	155,961	138,736	834,239.74	1,124,103.09	878,875.29
Fresh:						
From United States	995,746	1,888,399	1,093,299	10,707,195.43	12,293,689.03	11,141,934.46
From other countries	184,648	215,456	326,972	1,575,811.63	1,575,154.65	2,381,626.16
Total	1,180,394	1,403,855	1,420,271	12,283,007.06	13,868,843.68	13,523,560.62
Meat unenumerated:						
From Holland	83,865	74,896	116,833	917,125.98	796,879.64	1,213,919.21
From United States	13,839	19,097	21,351	143,332.52	173,943.30	176,736.66
From other countries	27,905	30,729	33,098	319,067.19	359,103.89	335,569.50
Total	125,605	124,722	171,282	1,379,525.69	1,329,926.83	1,726,225.37

[1] In hundredweights of 112 pounds.

Table showing the quantity and value of meat, preserved otherwise than by salting, imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

Product.	Quantities[1] for eight months ended August 31—			Values for eight months ended August 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Beef	239,385	176,724	302,453	$2,829,957.33	$2,384,891.58	$3,657,427.80
Mutton	57,050	77,113	126,569	523,898.18	658,588.24	1,017,536.48
Other sorts	86,666	98,790	122,138	1,519,506.22	1,591,729.95	1,825,448.48
Total	383,101	352,627	551,160	4,873,361.73	4,635,209.77	6,500,412.76

[1] In hundredweights of 112 pounds.

The number and value of cattle imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

From—	Number for eight months ended August 31—			Values for eight months ended August 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Canada	54,600	48,920	54,262	$4,751,700	$3,979,000	$4,463,000
United States	157,157	273,678	176,470	14,309,000	23,763,000	15,416,000
Argentina	5,643	7,831	25,165	433,472	580,000	1,981,000
Other countries	77	89	672	9,934	10,000	60,156
Total	217,477	330,518	256,569	19,504,106	28,332,000	21,920,156

Average wholesale prices of dressed meats at the London Central Meat Market, 1894–95.

[Per 100 pounds. Compiled from the Board of Agriculture returns and from the Meat Trades Journal.]

Product.	First quarter, 1895.		Second quarter, 1895.		Third quarter, 1895.		Average for 1894.	
Scotch:								
Short sides	$12.12½–	$12.87½	$13.12½–	$14.12½	$12.12½–	$14.62½	$12.62½–	$13.62½
Long sides	11.25	11.75	12.12½	12.62½	12.12½	13.62½	11.37½	11.75
English prime	11.25	11.75	11.75	12.37½	11.00	12.87½	11.12½	12.37½
Cows and bulls	7.75	9.25	7.25	9.75	6.00	10.00		
American:								
Deptford killed	10.50	11.00	11.00	11.50	9.00	11.50	9.25	11.00
Birkenhead killed	10.50	11.00	10.75	11.50	9.75	11.50	9.25	11.00
Refrigerated hind quarters	10.50	11.50	11.75	12.87½	10.50	13.50	9.12½	10.62½
Refrigerated fore quarters	8.00	8.75	6.25	7.75	4.50	7.50	5.25	8.00
Australian frozen hind quarters					6.50	7.00		
Argentinian Deptford killed			9.00	10.25	8.00	10.00		
Mutton, Scotch prime	14.62½	15.37½	14.37½	15.62½	14.12½	16.62½	12.12½	14.60
English prime	14.12½	15.12½	13.87½	15.12½	13.12½	15.12½	12.00	15.12½
Ewes	11.25	12.37½	10.50	11.50	9.50	12.12½	10.00	12.12½
Dutch and German	12.37½	13.37½	12.87½	13.87½	12.12½	14.12½	10.00	13.62½
New Zealand, frozen	6.25	7.75	5.00	6.75	6.00	8.00	6.50	8.00
Australian, frozen	5.50	6.00	4.75	5.50	6.00	7.00	5.75	8.00
River Plate:								
Frozen	5.50	6.00	4.75	5.50	6.00	6.50	5.25	7.50
Town killed	11.00	12.12½	9.00	10.50	9.50	11.00		
Lamb, English	18.37½	21.50	17.62½	20.62½	15.12½	19.62½	14.00	23.00
New Zealand, frozen	8.75	11.25	7.75	9.75	7.50	9.50	9.62½	12.00
Pork, English, small	10.50	11.50	10.00	11.00	9.00	12.12½	11.12½	15.12½
English, large	8.75	10.50	7.75	9.50	6.00	9.00	10.37½	12.12½
Foreign	8.75	10.50	7.75	9.50	6.00	9.00	10.37½	12.12½

Imports from Ireland into Great Britain of cattle, sheep, and pigs during the first eight months of 1895.

Cattle	402,707
Decrease (as compared with same period last year)	32,546
Sheep	453,840
Decrease	214,000
Pigs	323,891

Average prices (wholesale by the carcass) per 100 pounds of beef and mutton in Liverpool, Berlin, and Paris.

City and product.	Quarter ended— Mar. 31, 1895.	June 30, 1895.
Liverpool:		
Home grown[1]	$8.50-$11.00	$8.00-$11.50
States cattle[2]	10.00 10.50	10.00 10.75
Canadian cattle[2]	9.75 10.50	9.00 10.50
Colorado cattle[2]	9.75 10.50	9.00 10.50
South American cattle[2]	9.00 10.25	7.50 9.50
Mutton (home grown)[1]	10.00 15.00	11.00 15.50
Berlin:[3]		
Beef (first quality)	13.10 13.90	12.58 13.03
Mutton (first quality)	10.35 10.90	10.10 10.70
Paris:[4]		
Beef (medium quality)	13.40	12.42
Mutton	16.35	16.45

[1] From official report to Board of Agriculture.
[2] Compiled from prices in Meat Trades Journal.
[3] From Deutsche Landwirthschaftliche Presse.
[4] From Journal de l'Agriculture Pratique.

Average prices per 100 live pounds of domestic cattle in certain English and Scotch markets for the first six months of 1895 and 1894.

[From official sources. It should be noted that these are *live* weights.]

Location of market.	Inferior or third quality.		Good or second quality.		Prime or first quality.	
	1895.	1894.	1895.	1894.	1895.	1894.
London	$6.26	$6.11	$7.60	$7.73	$8.00	$8.38
Liverpool			6.04	6.12	7.43	7.30
Newcastle			7.25	7.28	7.62	7.67
Shrewsbury	5.65	5.31	6.95	6.18	7.47	7.16
Aberdeen	5.46	5.42	6.95	6.95	7.82	7.85
Dundee	5.95	5.73	7.17	6.95	7.47	7.38
Edinburgh		5.40	7.65	7.25	7.59	7.40
Perth	7.00	6.56	7.20	6.96	7.69	7.38

Average value per 100 pounds of dead meats imported into the United Kingdom.

[Compiled at the Board of Agriculture from the trade and navigation accounts.]

Product.	First quarter, 1895.	Second quarter, 1895.	Average for the last nine months of 1894.
Beef:			
Fresh	$8.79	$8.46	$8.56
Salted	5.75	5.57	5.90
Mutton, fresh	7.67	7.75	8.00
Pork:			
Fresh	9.41	10.46	10.36
Salted	6.42	5.47	6.12
Bacon	8.00	8.30	9.30
Hams	9.33	9.63	10.71

In 1895 there were about 30,000,000 sheep in Great Britain. The falling off in English flocks during the last few years has been very marked. Prices have been, however, firmly maintained for mutton, notwithstanding the great increase of the importations of live sheep and frozen mutton. The United States shipped more than three times as many sheep to England this year as in 1894. Argentina increased her shipments of mutton to the same markets from 53,000 to 240,000, but Canada remained practically stationary at about 50,000 head. No law compels the slaughtering of these animals at the port of debarkation. Many of them, therefore, are fattened upon English pastures and sent to market as English. This is probably the principal reason why the table herewith submitted shows no quotations for American mutton as such:

Table showing the quantity and value of mutton imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

From—	Quantities[1] for eight months ended August 31—			Values for eight months ended August 31—		
	1893.	1894.	1895.	1893.	1894.	1895.
Germany	16,301	7,017	5,368	$198,918.18	$83,007.88	$62,276.59
Holland	72,724	67,958	62,830	834,930.80	755,363.51	679,095.74
Australasia	865,932	945,449	1,163,953	8,267,108.00	9,032,520.85	10,658,097.31
Argentina	352,156	367,900	469,670	3,201,928.27	3,296,912.62	3,162,928.14
Other countries	41,881	58,436	45,509	507,152.55	635,287.50	433,420.22
Total	1,348,994	1,446,760	1,747,330	13,010,037.80	13,803,092.36	14,995,818.00

[1] In hundredweights of 112 pounds.

The Journal of the British Board of Agriculture for the month of September last says:

Taken in conjunction with the large increase in the arrivals of live sheep, it is noteworthy that, roughly computing the number of carcasses represented by the total weight of mutton received and adding this to the sheep imported alive into the United Kingdom, the total receipts of mutton alive and dead indicate an importation equivalent to 3,000,000 head of sheep in the half year ended June 30, 1895.

The above quotation indicates that the British consumption of imported mutton amounts to 6,000,000 head of sheep in a single year; and as there is no international agreement fixing the price of meats in the English market, the relation of the supply of meats to the demand for meats will continue to regulate the values, and those who can produce beef, pork, and mutton and place it in the European markets at the least cost will secure a monopoly of the trade. The struggle for the privilege of purveying food to consumers in all the markets of the civilized world was never before so strenuous, and neither national legislation nor international treaties can permanently retard, repress, increase, or encourage exchanges between the civilized peoples of the globe. That trade which is profitable will continue in spite of legislation, and that which is unprofitable can not be legislated into remunerative conditions.

THE WORLD'S MARKET FOR AMERICAN HORSES.

During the first eight months of the year 1893, 10,177 horses, in the same period of 1894, 15,614 horses, and during the eight months ended August 31, 1895, 22,755 horses from the United States were landed and sold in Great Britain, this last exportation being valued at $2,947,000.

The average price of American geldings in the English market during the first eight months of the year 1895 was $155.50. Geldings from Canada during the same period of time averaged $141 each, while those from Germany during the same months in the English market averaged only $56 per head. However, as the appraised or entered values of horses at custom-houses, where they are free of duty, is altogether an arbitrary matter, too much weight should not be given to the per capita valuations above, as they can not more than approximately represent the real subsequent selling value of the animals. The low valuation of German geldings indicates that those shipments are of an inferior class of horses which can not compete with American animals. The fact is Germany herself is a very large importer of a fine quality of horses from Russia, and animals of superior merits always find a market in Berlin and the other large cities of the Empire.

The Department of Agriculture is credibly informed that Germany has taken during the past year almost as many horses from the United States as did Great Britain in 1892, showing that opportunity exists also there for intelligent horse breeders in the United States.

Twenty-seven hundred mares were sent from the United States into the British market during the first eight months of this year, as against 461 for the same period last year and 112 for the year 1893. The average value per head of American mares this year was $134. It will be observed that this price is much lower than that of geldings. It indicates that no superior mares for breeding purposes were exported from the United States.

In September, 1895, some good carriage horses were received in England from this country. They were of fine appearance, well gaited, thoroughly broken, and free from blemish. The best of them sold at $230 single, and as low as $300 for a matched team. The demand for such animals at that time seemed to be quite abreast, and possibly a little in advance, of the supply.

Europeans who have bought and used American horses generally express a very favorable opinion of them. The horses from the United States which have been criticised have been confined to a limited number of heavy-weight draft horses. Up to date some of the great transportation companies in London which are using American horses decline to give positive expression of their opinions regarding their qualities and durability. The London Roadcar Company, however, is using a great number of American animals, for which it

has paid from $100 to $175 a head, and the managers of that corporation unhesitatingly declare that the imported horses wear as well as the home bred, and that they acclimatize with facility and celerity. The Andrews-Star Omnibus Company, of London, is also using many American horses, which they purchased through London and Newcastle-on-Tyne dealers. Inquiry shows that there are many other establishments in England utilizing American horses, including the Great Eastern Railway Company, which has paid as high as $190 to $220 per head for imported draft horses.

Editor McDonald, of the London Farmer and Stock Breeder, writes:

From what I have been able to learn, it seems to me too early yet to pass any opinion regarding the future of the trade. The warm climate of London gives the American horses every opportunity of doing well. In Scotland acclimatization is much more difficult, and hence it is found that three months' hard work on the causeway reduces them to skin and bone. The custom is largely pursued there (in Scotland) of buying animals from the ship and feeding them into good condition. By this means the farmer is enabled to reap a substantial profit with half the trouble and risk involved in breeding. This system is hardly pursued at all in England. Dealers usually hold large strings, and the horse repositories, through which the bulk of the trade is done, are called upon to meet the demand. The market at present is rather depressed, as is the market for home breeds.

AMERICAN HORSES IN GLASGOW.

The trade in horses from the United States began to assume growing proportions in the city of Glasgow in the year 1891, during which the Dominion Line took into that city 114 horses. But in 1892 it carried in 147 head; in 1893, 137 head, and in 1894, 209 head. Since 1891 the Allan steamers have also carried to Glasgow 7,500 horses, and out of that number about 3,000 arrived in 1894. The total number of horses taken into Scotland from the United States and Canada in four years has not been less than 10,600. During the same period of time the Scotch export trade has fallen from 1,100 to 20 horses, while the American import trade at Glasgow has grown to about 4,000 animals. Most of the American horses there were natives of the Western States, though shipped from Montreal, Portland, Boston, and New York. As a rule, they have been light wagon or carriage horses.

From reputable sources in Glasgow this Department learns that the importation of American horses is now engaging the serious attention of dealers and contractors in that city. The Department is further informed that the larger proportion of horses received there from the United States have given entire satisfaction to their purchasers, and that the only disappointing animals shipped from this country have been a few of the Clydesdale type, which have shown a markedly rheumatic tendency. If horses of a useful size, trained for roadsters and likewise adapted to ordinary wagon work—something after the style of Cleveland bays—are shipped from the United States to Glasgow they will, as a rule, find a ready and profitable market. Heavy horses, likewise, weighing from 1,300 to 1,500 pounds, in matched

pairs, may be shipped at current prices to that port with a probable profit, though it might prove unprofitable to send in a large number of such animals at the same time.

It seems now to be generally conceded in Great Britain that it is cheaper to import American horses than to produce horses in that Kingdom. It is also pretty universally admitted that the Canadian carriage horses are inferior to those exported from the United States, though the Canadian animals are claimed to possess, as a rule, greater power of endurance. There are now a number of reputable firms of agricultural salesmen in England and in Scotland, at London and at Glasgow, to whom consignments have been made by Americans with quite satisfactory results. Immediately upon the arrival of steamers carrying horses, or within a few days after landing, the animals are exposed for sale at auction. They are readily purchased by contractors and others who require them for their own use, and thus there are very few transactions through middlemen.

INSPECTION OF HORSES FOR EXPORT.

In view of the growing foreign market for American horses, the Bureau of Animal Industry, under existing laws, will soon institute a thorough and rigid veterinary inspection of all horses for exportation. This, it is hoped, will preclude the possibility of the growth of the trade being impaired or suppressed by the foreign protective or agrarian element upon alleged sanitary grounds. After inspection each animal will be tagged and described so that identification will be easily made upon landing should any communicable or contagious disease be alleged to affect a horse in any lot shipped from the United States.

It is important that the law providing for meat inspection be amended in several particulars. The suggestions of the Chief of the Bureau of Animal Industry (page 104, report 1895) are worthy of immediate consideration by the legislative branch of the Government. Unless the law can be perfected it can not be satisfactorily administered, nor can needed additional regulations be instituted and carried out.

DAIRY PRODUCTS.

CHEESE.

Throughout the year United States cheese has commanded the minimum figure upon the English market, and as by the operation of an invariable law the lower grades always suffer the most by a material fall in prices, our cheese has suffered disproportionately to other makes by the depressed condition of the English cheese market, and has reached in 1895 the lowest price yet quoted for American cheese in that country, namely, $2.17 per 100 pounds.

Our agent and correspondent reports in explanation that "United States cheese is, as a whole, the poorest in quality that reaches the English market, and the British public are not only aware of the fact but are prejudiced against it because so much in the past has been adulterated." While accusations that "filled cheese" is being dumped on the British markets from the United States go unrefuted, the very first statement impugning the Canadian product in the same manner was met with cabled denials from the Canadian Government; denials from the Canadian agent-general in London and Canadian exporters. The incident, it seems, has actually turned out to be an excellent advertisement for Canadian cheese, and it is now perfectly well understood by the British public that Canada is maintaining with strenuous care the quality of her exports.

During the first eight months of last year Canada and the United States stood side by side in supplying the English market with cheese; but whereas Canada has this year not only held her own, but made a slight gain, shipments from the United States have fallen off 117,000 hundredweight, an amount about corresponding to the increased shipments of Australasia and Canada and to the falling off in the total imports into Great Britain. In fact, every country shipping cheese to Great Britain has this year enlarged its trade with that country except the United States, which has lost over 21 per cent of its last year's business.

The following table represents the quantity and value of cheese imported into the United Kingdom:

Table showing the quantity and value of cheese imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

From—	Quantity (cwts. of 112 pounds).			Value.		
	1893.	1894.	1895.	1893.	1894.	1895.
Holland	174,009	185,904	200,581	$2,128,135.05	$2,302,681.81	$2,479,423.35
France	38,355	33,812	37,532	579,877.53	504,003.93	566,781.78
Australasia	36,180	50,256	92,160	456,613.95	622,522.68	1,063,155.04
Canada	480,642	531,188	533,612	5,844,160.42	6,037,735.15	5,289,647.03
United States	522,461	538,741	421,946	6,277,775.25	6,280,412.91	4,560,221.94
Other countries	12,638	3,269	14,074	155,976.18	403,194.38	171,252.13
Total	1,264,285	1,372,670	1,299,905	15,442,538.38	16,150,550.86	14,130,481.27

BUTTER.

Shipments of butter from the United States represent almost 1 per cent of the total imported into Great Britain. Denmark still holds the lead of all competitors in supplying this great butter market, others being France, Australasia, Sweden, and Finland, in the order named.

Table showing the quantity and value of butter imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

From—	Quantity (cwts. of 112 pounds).			Value.		
	1893.	1894.	1895.	1893.	1894.	1895.
Sweden	185,009	176,158	203,785	$4,873,347.16	$4,560,309.55	$5,231,623.75
Denmark	649,779	762,774	791,037	17,365,136.81	19,599,215.57	18,949,396.69
Germany	132,149	111,257	92,537	3,192,920.38	2,763,208.43	2,246,434.79
Holland	94,838	104,556	128,687	2,381,786.76	2,511,313.52	3,009,331.67
France	319,575	267,442	296,940	8,791,259.24	7,253,620.44	7,692,919.39
Australasia	101,095	203,760	245,940	2,529,567.76	4,865,020.57	5,306,567.85
Canada	13,232	2,908	8,353	277,989.07	56,568.18	155,737.73
United States	19,793	26,936	19,371	436,291.45	552,235.82	365,970.53
Other countries	77,216	99,281	129,318	1,917,376.66	2,384,249.19	3,085,589.72
Total	1,592,776	1,755,072	1,915,968	41,765,675.29	44,545,741.27	46,043,572.12

No one can carefully peruse the above facts and figures without arriving at the conclusion that unless our shippers of cheese pursue a very different course our foreign trade in that product will speedily fall, in the face of active, intelligent, and honest competition from all parts of the world, to the level now occupied by American butter. We have here a graphic illustration of the disastrous effects in all trade of disregarding the tastes of consumers and of acquiring a bad reputation.

SUBSIDIARY FARM PRODUCTS.

The importance of the subject to American farmers, who must learn to make up from subsidiary products, and, if necessary, in small sums, the losses entailed by low prices for staple crops, suggests reference to two so-called minor crops, one of which, eggs, is not quite sufficient to supply our own consumers, and the other, honey, affords us a little surplus for which there is a foreign demand, which, by intelligent and assiduous cultivation, could doubtless be greatly developed.

The importance of the following table to poultry keepers is seen in the evidence it presents of a large foreign market of which we not only get no share, but in which we actually figure as purchasers ourselves:

Table showing the quantity and value of eggs imported into the United Kingdom during the first eight months of the years 1893, 1894, and 1895.

From—	Quantity (great hundreds).			Value.		
	1893.	1894.	1895.	1893.	1894.	1895.
Russia	825,037	744,425	1,243,262	$1,055,908.83	$910,395.62	$1,525,608.81
Denmark	630,191	754,762	712,662	1,007,818.08	1,200,993.80	1,136,199.02
Germany	1,199,894	2,256,924	2,331,922	1,704,085.50	3,103,629.83	3,055,242.22
Belgium	1,167,599	2,109,085	1,528,905	1,984,247.23	3,045,246.43	2,230,231.32
France	3,046,727	1,804,327	2,039,535	6,283,576.13	3,540,198.68	3,859,153.96
Canada	23,065	23,277	79,463	33,802.70	37,218.99	144,904.89
Other countries	138,413	120,521	171,613	247,719.45	189,146.25	299,576.87
Total	7,030,926	7,818,321	8,107,362	12,317,157.92	12,026,829.60	12,280,917.09

HONEY.

The English honey market is supplied by the home product, from the United States, and from Chile. There is a large and steady demand, and, though sometimes exceeded by the supply, this is an unusual occurrence. The English honey harvest has been very good this year, and it is selling upon the retailer's counter at from 20 cents to 25 cents per pound. Wholesale prices at the latest date obtainable are as follows:

English: Earthenware pots, finest, per doz	$1.45
Earthenware pots, finest, ½-pound, per doz	.90
Flint-glass jars, 17-ounce, per doz	1.70
Transparent honey, in glass jars, nickel-plated screw top, per doz	1.57
United States: Thurber-Whyland's white sage, strained, 1-pound jars, 2 dozen in a case, per doz	2.30
Californian, in original cans (about 56 pounds), per cwt. of 112 lbs.	9.60
Chilean, in original cwt. kegs, per cwt	8.75

The American white sage commands the top price. It is a delicious honey and most attractively put up. All honeys sent to England are strained except a nominal quantity that reaches there in the comb from California. California shipments of strained honey are made in 56-pound tins, two tins in a case. Chilean usually comes in 60-pound kegs, but sometimes in 112-pound barrels. It is not a matter of great importance, as to size of packages, etc., though it would be well to conform to the California practice. It would be ruinous to send adulterated honey to England.

Our agent in England has had several inquiries as to honey market this year, especially from Texas, and he has supplied inquirers with names of importers in England, and with information as to how to approach them, and this he will be pleased to do for all inquirers.

The Department has knowledge that some years ago a large honey maker in California found in China a profitable market for some 20 tons of honey annually.

In this, as in every other branch of industry, only the makes of the best, most genuine products can secure a permanent, profitable trade, creditable alike to themselves and their country, and they alone deserve to.

WEATHER BUREAU.

For the fiscal year ended June 30, 1895, Congress appropriated $878,438.84 to maintain the United States Weather Bureau. Expenses, however, were reduced while the efficiency of the service increased, so that there remains approximately a sum of $55,000 which will ultimately be covered back into the Treasury of the United States out of the appropriated amount. During the same twelve months the Weather Bureau received for condemned property, sale of publications, and seacoast telegraph lines, and deposited in the Treasury

of the United States, the additional sum of $5,498.57, making a total to be covered in by this Bureau of something over $60,000.

FORECASTS.

Detailed statements as to forecasts published during the year in the different States and Territories of the Republic are contained in the annual report of the Chief of the Weather Bureau. That report also gives approximations of the value of property saved because of those forecasts, and declares that the warnings of cold waves alone secured from freezing more than $2,275,000 worth of perishable agricultural products which otherwise would have been lost. It is proved by the report of the Chief of the Weather Bureau that the degree of accuracy in the forecast division thereof is steadily augmenting. It is now a duty, under orders from the Secretary of Agriculture to the Chief of the Weather Bureau, that reports be made on the first day of each month of all forecasts made for the previous thirty days, together with the percentages of their verification.

Thus every forecaster realizes that his work is to be reviewed at the close of each four weeks and his accuracy tested by mathematical computation and verification. This feature in the administration of the Weather Bureau has been adopted since Prof. Willis L. Moore was appointed chief of that bureau and entered upon his duties, July 4, 1895. Since that date many reforms have been successfully instituted, and thus far the service continues to show a marked and decided improvement as to its management and efficiency.

The present Chief of the Weather Bureau began his profession in an observer's station twenty years ago. He came up from the ranks of the intelligent and industrious workers. In 1894, at a competitive examination, which had been instituted by the Secretary of Agriculture, for a $2,500 professorship, it was decided, after a severe contest and examination by Professors Harrington and Mendenhall and Maj. H. H. C. Dunwoody, of the Signal Corps of the Regular Army of the United States, that Prof. Willis L. Moore was entitled, by ability and acquirements, to the place. Thereupon, he was detailed to take charge of the Weather Bureau station at Chicago. He gave an entirely satisfactory and markedly useful service in that city. From there he was called to his present position. His success and promotion opens the way for advancement, through industry, skill, and attainments, to every observer in the Bureau.

The possibilities of usefulness to agriculture, manufacture, and commerce are almost without limit in the increasing accuracy and capabilities of the Weather Bureau. The time is not probably very distant when its records, warnings, and forecasts will be constantly in demand as evidence in the courts of justice and also by those purposing large investments in certain kinds of agricultural crops, in

perishable fruits, in commercial ventures, and in manufacturing plants. Weather Bureau forecasts in the not distant future will, no doubt, be consulted and awarded credibility just as thermometers, barometers, and aerometers are to-day. The usefulness of the meteorological branch of the service, wisely and economically administered, is beyond computation. The annual report of the present chief is replete with interesting and practical suggestions.

DIVISION OF STATISTICS.

The work of the Division of Statistics, in charge of Henry A. Robinson, its chief, is, primarily, collecting, through many thousands of unpaid county correspondents in the several States and Territories of the Union, agricultural data as to area, condition, and probabilities of crops. After this data has been tabulated, averaged, and consolidated it is given to the general public in the form of approximations as to acreage, condition, and yield.

From its origin, the conclusions and reports of this division have been frequently subjected to more or less severe criticism. Public attention is often called to the fact that the annual cost of securing agricultural statistics which are published from time to time by this Department is about $100,000, and that therefore they ought to more nearly attain accuracy. The authors of these criticisms forget that while about that sum of money is exhausted annually in the payment of certain State statistical agents and the employees and expenses of the division in the city of Washington, 10,000 county crop reporters in 2,500 counties throughout the several States and Territories of the American Union perform their duties without any pecuniary remuneration whatever.

Added to the foregoing unremunerated force there are 15,000 millers and elevator men who send in figures and data from month to month relative to cereal and other crops, and also 15,000 township correspondents who do the same thing, and 6,300 agents who report to the several State statistical agents, who condense and send to this Department the results of their inquiries and estimates, and added to this last list are 3,000 special cotton-crop correspondents; and supplementing all the foregoing there are 123,000 American farmers who have been selected because of their large experience and superior intelligence who assist (by making special investigations) in verifying the vast amount of data and figures furnished by the tens of thousands of correspondents enumerated. And not a single one of the aforesaid correspondents among the farmers, elevator men, millers, and other intelligent classes of citizens named receives a dollar of salary out of the Treasury of the United States. The marvel, therefore, is that the data thus patriotically and freely furnished the Division of Statistics should prove as valuable, reliable, and accurate as it does.

The statistical system of this Department at present, consequently, provides for the payment of collating and disseminating data evolved from facts and figures which have been furnished to its various sections and officers in Washington as mere gratuities. The fact that some citizens are paid fair salaries for industriously and correctly making computations, averages, and approximations, and determining results from conditions and figures which have been gratuitously collected and sent in by other citizens who were wholly without compensation, is not calculated to inspire great faith or credibility as to the reliability of the conclusions reached. During the past year, however, in addition to the usual county and township crop correspondents, generally belonging to the agricultural classes, the Department has secured from month to month data from millers throughout the country, from railroad managers, from railroad station agents, and from bankers, merchants, and nearly every other intelligent source of information. During the last twelve months a visible improvement as to the accuracy of figures promulgated has been developed relative to the cotton and some other crops, and yet the condition of the division and the fruits of its labors are not entirely satisfactory.

Neither individuals nor governments can, ordinarily, successfully and permanently obtain a valuable gratuitous service. Humanity seldom gives, either to citizens or governments, something for nothing, except in cases of poverty and distress. It is, therefore, the opinion of the Secretary of Agriculture that no satisfactorily accurate statistical work can be accomplished for agriculture and commerce by this Department until a sufficient permanent appropriation shall have been made to provide for the taking of an annual agricultural census. Others who have made this subject a profound study, and whose judgment is entitled to great consideration and respect, believe that reliable detailed data may be gathered by the assessors of taxes in the various States and Territories. Others again, of equal experience in statistical research, declare that the collectors of internal revenue and their deputies and other employees could be successfully commanded by the Treasury Department for the collection of agricultural statistics.

Again, men of great experience in the cereal and cotton trades claim that if the acreage be accurately ascertained as to each staple product, and that acreage published in the month of June each year, and additionally the climatic conditions in each locality be also officially promulgated each day or week or month during the growing season, more accurate approximations of crops can be reached than by any other method.

It is possible, in the opinion of the Secretary, that the duty of ascertaining and reporting to this Department accurately the acreage of staple crops in each State on June 1 of each year might be, without working any hardship, imposed by law upon the authorities of our

agricultural colleges and experiment stations in consideration of their united annual appropriation of $40,000 each. The acreage being given, the character of soil known, and climatic conditions published daily by the Weather Bureau, approximations of the yields of each crop could be probably computed with more accuracy than under the present methods.

Attention is particularly directed to the report of the chief of this division, which in detail and very clearly describes its work during the fiscal year, and likewise reiterates cogently an argument in favor of taking an annual agricultural census. It concludes that if there be value in statistics as now gathered and published there would be infinitely greater value and use for statistics based upon absolutely accurate returns made by the takers of a yearly farm census.

If, however, the Congress of the United States finally provides for a permanent census bureau to gather populational, agricultural, commercial, and manufacturing statistics each year, instead of once in ten years, the entire business of collecting agricultural data and statistics should be vested in that bureau, which is now proposed and advocated as a permanency by many of the most thoughtful economists and statists of the United States.

EXPERIMENT STATIONS.

The Office of Experiment Stations continues in charge of Dr. A. C. True as Director.

In his report for 1893 the Secretary of Agriculture recommended that he be given authority to supervise the expenditures of agricultural stations; this had not been done before. In pursuance of this suggestion the Fifty-third Congress inserted the following sentence in the paragraphs providing the usual appropriation for these stations:

> The Secretary of Agriculture shall prescribe the form of annual financial statement required by section three of the act of March second, eighteen hundred and eighty-seven; shall ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of the said act, and shall make report thereon to Congress.

The blank schedules for reports and instructions for filling them up were prepared and distributed to the experiment stations as soon as practicable after the passage of this act. The new law applied to the appropriations made for the fiscal year ended June 30, 1895. Under the original experiment-station act the reports of these stations are not due until February 1, 1896. A complete report on their work and expenditures during the past fiscal year is therefore not possible at this time. This will, however, be prepared as soon as practicable for transmission to Congress. It is respectfully recommended that the original experiment-station act be amended so as to require the financial reports of the stations to be rendered to the Secretary of Agriculture on or before September 1 following the close of the fiscal year.

Thus it will be possible thereafter to include a report on their expenditures as a part of the Annual Report of the Secretary of Agriculture.

In order that the Department might have accurate and complete information regarding the work and expenditures of the stations as the basis for the report to be made by the Secretary of Agriculture, it was decided that the stations should be visited by representatives of the Department. Up to the end of the fiscal year 35 of these stations were thus visited. In connection with these visits inquiries were made regarding the general management of the stations and their relations to the colleges; their methods of keeping accounts and records of their work; the lines and methods of work undertaken, and all other matters which might throw light upon the expenditures as reported.

WORK OF THE STATIONS.

In regard to the work of the stations the Assistant Secretary of Agriculture, Dr. Charles W. Dabney, jr., says:

In a general way it may be said that the investigation of the work of the stations thus far made clearly indicates that even the poorest of our stations have done scientific work of practical benefit to the farmers of their communities, and that in many cases the services of the stations already rendered have been of great value to practical agriculture, far surpassing in the aggregate the total amount of expenditure made for them by the National Government. The greatest hindrances to successful work have arisen in those communities which have failed to appreciate the fact that the stations are primarily scientific institutions, and that, while they should always keep steadily in view the practical results to be obtained, they render the most permanent benefits to agriculture when they make thorough scientific investigations of problems underlying successful agriculture and horticulture.

The importance of adopting definite lines of work and sticking to them until definite results have been obtained is strongly urged. In order to accomplish this there should be greater permanency in the organization and tenure of office of the stations, as frequent changes in boards of management and station officers have caused corresponding changes in the policy and work of many of the stations, which have either prevented their carrying out any thorough inquiries or discouraged the undertaking of important investigations.

In some cases the institutions with which the stations are connected have not received that support from the States which was necessary and was evidently contemplated under the acts of March 2, 1887, and August 30, 1890. In all of the acts from the land-grant act of 1862, providing the first endowment for colleges of agriculture and mechanic arts, down to the act of August 30, 1890, making a handsome addition to the income of the same institutions, it is clearly implied that the States shall provide the necessary land and buildings for these colleges as well as the experiment stations connected with them. The United States has provided a part of the funds necessary for paying the current expenses of these institutions, but in doing so it places the obligation upon the States to provide the necessary land, buildings, and other things belonging to the plant. In all such cases this Department has sought to bring the local communities to realize more fully the importance of contributing from their own means to build up strong institutions for the benefit of agriculture.

THE NUTRITIVE VALUE AND ECONOMY OF FOODS.

The supervision of the investigations on this subject was assigned to the Office of Experiment Stations, with Prof. W. O. Atwater as special agent in charge. In accordance with the terms of the law, the cooperation of the agricultural experiment stations has been sought as far as was justified by their facilities and the requirements of their work. As a rule, only such institutions were invited to join in this work as were in a position to contribute the services of experts, laboratory facilities, and other resources to supplement those provided by this appropriation. In this way work has been carried on under the immediate direction of Professor Atwater at Middletown, Conn.; in connection with the Society for Improving the Condition of the Poor and the Industrial Christian Alliance in New York City; in connection with the New Jersey State Experiment Station at New Brunswick; at Pittsburg, Pa.; at Charleston, S. C.; at Suffield, Conn.; in connection with the agricultural experiment station at Auburn, Ala., and the Tuskegee Normal Institute, in Alabama; in connection with the University of Missouri, at Columbia; the University of Tennessee, at Knoxville; Purdue University, at Lafayette, Ind.; the Hull House, at Chicago, Ill., and the Maine State College, at Orono, Me.

The work has included so far the following lines: Studies of the composition, nutritive value, and cost of food materials; studies of actual dietaries, with a view to learning what are the kinds and amounts of food materials actually consumed by people of different sections, of different occupations, and under different conditions; studies on the digestibility of food; methods of investigation of food subjects, etc. The results of inquiries on food conducted in this country and abroad have been compiled, and already one technical and several popular publications have been prepared and published.

A standard table of the results of food analyses is in course of preparation. Many food materials never before analyzed have been analyzed by our agents, and during the year the number of food analyses tabulated has increased from about 1,100 to 3,000. When completed, this standard table of analyses will form an important advance in the study and will furnish a basis for future investigation.

An effort will be made to build up centers of inquiry where the more scientific and fundamental problems can be investigated, where workers in this line can be trained, where the importance and usefulness of accurate information regarding the rational nutrition of man will be taught to large bodies of students, and from which the practical results of food investigations may be widely and efficiently disseminated among all the people. The results of this work thus far published have awakened great interest in the subject, especially among physicians, teachers, clergymen, the officers of our Army and Navy, the superintendents of benevolent institutions, and persons

studying the sociological conditions of modern times. The investigations already made plainly show the wastefulness of the dietaries of a large number of people, and the importance of practical instruction in regard to proper methods of preparing and cooking food.

The work of the experiment stations is so varied and voluminous that no adequate conception thereof can be obtained except by a careful perusal of the report of the Director of the Office of Experiment Stations, to which you are respectfully referred.

FORESTRY.

The timber investigations have been continued and have received most of the attention and the largest share of the appropriation for this division, of which Prof. B. E. Fernow is chief. They are the most comprehensive experiments of the kind ever undertaken, and include tests of the average values of strength for the various species, variation of strength in the various parts of the trees, the variation of strength of timbers containing different amounts of moisture, the effects of dry-kiln treatment, etc. Altogether 175 trees, representing 24 species and 5 different sites, have been collected during the year. The total collection to date for this purpose numbers 761 trees, representing 39 species, mainly of Southern timber. Thirteen thousand tests were made during the year, 340 of which were large columns and beams, and a large amount of material was placed in dry kilns for next year's work.

Results referring to the four Southern pines, representing 163 trees and over 24,000 separate values, have been computed and arranged for publication. These results show that the shortleaf and loblolly pine are inferior to longleaf and Cuban pine by about 24 per cent; that the wood near the stump is 25 to 30 per cent heavier and better than that of the upper log; that the wood produced by trees 25 to 60 years of age is the best, and that in old trees there is a variation of 15 to 25 per cent in wood and quality. Special experiments in shrinking and swelling of timber were continued, and it was found that the wood of all pines varies in proportion to its original weight. Treatment with high temperature under pressure does not, as has been claimed by owners of certain processes of wood treatment, do away with shrinkage either in pine or oak. These specimen results show the great practical value of these timber investigations.

A series of experiments have also been begun with the object of determining how far the great deterioration of resin, so often noticed by turpentine collectors, is due to unavoidable physiological causes, how far to existing practices, and how these practices may be improved.

A series of measurements of the rate of growth of white pine has been made in Wisconsin and Michigan, comprising detail measurements of over 400 trees and the determination of 13 acre-yields, including

measurements made in connection with the collection of material for timber investigations. There are now on hand measurements of 1,700 trees, mostly pines, spruce, and a few hard woods, in addition to 57 acre-yields. Over 500 of these measurements have been worked up and tabulated, and the results charted so as to show the growth and development. These results show, for example, that the long-leaf and Cuban pines both grow in height and thickness much faster than had been supposed. Trees of white pine over 200 years old have been found to have made over $1\frac{1}{2}$ cubic feet annually for a century and a half. This work will be made the basis of a discussion of profitable forestry, and shall be continued until the rate of growth and capacity for production of all of our important species is established.

A series of experimental plantings in the Western treeless country for the purpose of testing the best varieties of trees suitable for forest planting and the best methods of planting in the conditions prevailing there have been started in connection with the agricultural experiment stations in South Dakota, Nebraska, Kansas, and Colorado. It is proposed to continue these experiments for a number of years in the hope of getting material for a report on Western forest planting.

This division has continued most actively its propaganda work. Through publications and by correspondence, and through lectures and addresses before agricultural colleges, summer schools, and public meetings it has sought in every way possible to further the establishment of a forestry policy among the people of the United States. By the extension of Arbor Day it is endeavoring to educate the children in the schools and the young people in the academies and colleges to love trees and to plant them.

ARBOR DAY IN JAPAN.

In this connection it is interesting to note that through the agency of Dr. Northrup, of the United States, and of the vice-minister of education of Japan, Mr. S. Makino, Arbor Day has been taken up by the teachers of that progressive country, with the prospect of its early establishment as a memorial day in all of its public schools. Through the courtesy of the Hon. S. Kurino, Imperial Japanese minister to the United States, the Secretary of Agriculture is able to present to you the following translation from a Japanese document, setting forth the movement and a carefully considered plan for Arbor Day, drawn up for the bureau of private revenue in the Imperial household department. This plan shows such an intelligent appreciation of the reasons for Arbor Day, and contains so many valuable suggestions with regard to the method of carrying it out, that it seems to merit special attention:

Some time ago Dr. Northrup, of the United States of America, came to Japan and had a talk with Mr. Makino, vice-minister of education, on the subject of

Arbor Day. About the same time the meetings of the presidents of normal schools were being held from time to time at the educational department, and the vice-minister took this occasion to explain at one of the meetings the purport of his interview with Dr. Northrup, recommending the advisability of the adoption of this system in Japan. Ever since then the question of Arbor Day has attracted the attention of educators in Japan. The following article is contributed to this office, embodying some remarks on the subject by one now living in Shizuoka, who has been in the service of the bureau of private revenue in the Imperial household department and who has had many years' experience in the forestry business:

"There are two objects to be attained by the adoption of a definite day for tree planting by the boys of our school—an Arbor Day—(1) To foster the idea of industry in the minds of schoolboys, divert them from indulging in bad practices, and cultivate among them botanical taste, besides affording intellectual pleasure and teaching them to look upon trees as the embodiment of love of home and country.

"(2) In addition, the practice might be made conducive to increasing the resources of the country.

"This system, if widely adopted, will be of indirect but great benefit, by inspiring dwellers in the country with the love of forests, thereby on the one hand reducing the danger of injury to them, and on the other promoting their growth. Other benefits to accrue, such as the prevention of sand falling, the protection from wind, the preservation of water resources, the addition to natural beauty and to the landmarks, the increase in the supply of fuel, are of vast importance to the country and the people.

"To simultaneously attain the two objects indicated above special heed must be given to following points:

"(1) *Plantation fund.*—There ought to be a fixed and permanent source of income. This needs no argument. Nothing, however meritorious, can be undertaken without such a fund, and nothing can be maintained unless the fund is stable. Especially is this the case with forestry, as the foundation principle of forestry economy is permanency, and the Memorial Day plantation ought to thrive with the age of the school.

"(2) *Selection of ground.*—This is the first step to be taken after the source of the fund is determined; but there will be great difficulty in getting proper ground, as it is at present even difficult to get proper space for school premises. It may, however, be comparatively easy to find a space of ground if we confine our object to those mentioned under A in a preceding paragraph, as we need not then look beyond the school ground, playground, garden, public garden, or roadside. If, on the contrary, we want to attain at the same time economic advantages, a choice must be determined by the following considerations:

"(*a*) *Area.*—A reasonable area is necessary, otherwise the space will be filled up very soon, which will make it impossible to continue the practice permanently or to utilize the land economically.

"(*b*) *Distance.*—The ground must be selected as near as possible to the school, otherwise it will be difficult to induce schoolboys to go there on Memorial Day. It will also entail expense. Moreover, it would be difficult to let the boys visit the grove frequently for future research into the theory of tree growth and to enjoy the observation of the several stages in the growth of the plant.

"(*c*) *Location and surface of the ground.*—Shrubby or grassy, steep or rocky land is objectionable on various grounds. But level ground being generally better utilized for farming, care must be taken not to employ it for this purpose, except in cases of sandy or poor ground fit only for forestry.

"(*d*) *Nature of soil.*—Every seed, properly selected, will grow even in poor earth,

unless it be rocky. But rich soil should be selected, because, in poor soil, growth being slow, schoolboys will fail to find pleasure in the natural development of the grove and will at last become indifferent.

"Above all, it is of the utmost importance to bear in mind that this matter should be so effected as to secure to the boys more pleasure than pain, and this with the greatest possible economical benefit.

"(3) *Selection of trees.*—The trees planted must be those best adapted to the soil which will produce the greatest possible benefit. To attain the two objects mentioned under A and B, the tree which will bear beautiful and fragrant flowers, or which will produce fine fruit, should be adopted. I should recommend pine, cedar, oak, camphor, etc. If a poor selection is made, the tree may not grow—may perhaps die—the boys will be disappointed, the teachers disheartened, and the expenses totally lost.

"(4) *Arbor Day or Memorial Day.*—It is desirable to select for Arbor Day some day especially memorable; but this is very difficult, as planting can not be done in every season, and trees planted out of the proper season generally die. The best way would therefore be to determine the date according to the respective localities and the kind of trees to be planted. The 11th of February (the day when our first Emperor ascended the throne), the 3d of April (the day when the same Emperor died), in the spring, and the 3d of November (the birthday of the present Emperor), in the autumn, may be good. But the spring season is recommended as most suitable for planting.

"(5) *Protection of young trees.*—The choice of trees to be planted being made, the means of obtaining the shoots must be determined. The best way would be to let the boys sow the seed and take care of the plants by spading the ground, cutting the grass, manuring, etc., as may be required, until the plants have grown sufficiently to be safely transplanted. This will enable them to become familiar with the different kinds of seeds and the different stages of their growth, and will promote fondness for the plants. This method is also applicable to small spaces which do not admit of the growth of plantations, and will enable us to obtain the desired plants at the proper time and in desirable places, while giving an immense advantage on the other hand in attaining the object mentioned under A. If, under certain circumstances, it is impossible to let the boys care for the plants, we must depend upon reliable and experienced dealers.

"(6) *The mode of planting.*—This must vary according to the kind of plants, the location and nature of the ground, and special care must be exercised in the transportation of the plants, cutting of the grass and prickly shrubs, and the tilling of the ground. Much depends upon the circumstances in each case, whether the boys have to do all the work, or whether they are to have assistance from coolies. If the boys do it all, those who supervise their work must fully consider details as to implements, and apportionment of space to planting, to the various classes of children, whether any and what distinction shall be made between male and female, between elder and younger, between higher and lower classes; whether shoots and modes of planting shall vary according to such distinctions. The growth of plants and the benefits resulting therefrom will differ greatly according as the manner of conducting the work is based upon the principles of forestry or not.

"(7) *Care and protection after planting.*—It is better not to plant the shoots than to leave them without protection. To plant them is easy, but it is difficult to make them grow into large trees. All requisite precaution, such as cutting spreading grass, protection against insects and worms, provision against fire, supplanting for decay, should be undertaken by the boys. But how boys are to undertake those precautionary measures, how they are to protect the tree for long years until it become fit to be cut as fuel, these are questions calling for special inquiry.

"There are many other points to be investigated, such as superintendence, control, keeping of records, utilization of principal and secondary products, etc.

"It would be improvident if, believing in the system of Arbor Day and approving it as feasible, one should try to at once apply it in practice without full consideration of means and methods. It is not easy, as stated above, to start the plan, and it is very difficult to carry it out successfully. The plan, if undertaken without proper care and full consideration of means and methods, would result in needless trouble and expense, and we should be not only unable to obtain good results but every tree and every plant would die, and both boys and teachers would be disheartened in spite of great encouragement from the other side."

CHEMISTRY.

This division, of which Dr. H. W. Wiley is chief, has received 1,420 samples for analysis during the fiscal year. It has completed 613 of these analyses, and the unfinished samples, consisting almost entirely of specimens received from divisions of the Department, can be worked up when time is found.

The investigation of food adulterations has been continued, being confined chiefly to the examination of cereal products and the manufactured articles therefrom. No adulterations of cereal products with gypsum, terra alba, and the like have been found in this country as they have frequently been found in Europe.

Active preparations have been made for carrying out "Investigations relative to the various typical soils of the United States to determine their chemical characteristics, especially the nature of the nitrifying organism contained therein," provided for in recent appropriation acts. The methods employed in the chemical and bacteriological examinations of soils have been systematized and studied. A vegetation house capable of holding about 200 pots for cultural purposes has been constructed and fully occupied. Through the cooperation of the experiment stations, samples of typical soils have been secured, and the chemical analyses, pot cultures, and bacteriological examinations are well under way.

PERVERSION OF OFFICIAL ANALYSES.

The people are frequently misled by perverted references to the analyses of this division by advertisers of baking powders, food products, etc., whose products have been analyzed in the course of investigations of food adulterations or other official work. There can be no objection to advertisers referring to the published reports of the Department in support of the virtues of the wares they offer for sale, but exaggeration, perversion, suppression, and misstatement of facts, attributed to official authority, should not be allowed. In the hundreds of advertisements that have been noticed in which the work of this division has been referred to, there is scarcely a single case in which the facts were accurately set forth as officially published. There is, therefore, just reason for complaint. It seems to the

Secretary of Agriculture that there should be some method adopted by means of which advertising misrepresentations of official analyses, intended originally to protect the people, could be prevented.

BOTANY.

The herbarium of the Department of Agriculture, commonly called the National Herbarium, having outgrown its old quarters, was, by the kind permission of the Secretary of the Smithsonian Institution, removed and well installed in the fireproof building of the National Museum, where it will be cared for by the botanists of this Department. This herbarium is steadily being built up and enlarged at the expense of the Department of Agriculture.

This division, with Mr. Frederick V. Coville as chief, has continued its investigation upon weeds, pure seed, poisonous plants, and other subjects mentioned in the last report. Several bulletins have been published calling attention to dangerous weeds, and a general bulletin on "Weeds; and How to Kill Them" was issued in the series known as Farmers' Bulletins. In addition to illustrations and special remarks regarding many of the weeds, it gives a tabular arrangement of the most important facts, from a practical standpoint, concerning about 100 of our common weeds, with brief instructions as to the best method of their eradication. A bulletin has also been prepared on the subject of weed legislation, consisting of the laws now in force in the different States, and suggestions for similar legislation by other States.

SEED TESTS.

The seed-testing laboratory of this division is doing much to educate American farmers, seed producers, and dealers in seeds with regard to the best methods of harvesting, cleaning, and preparing for market the various commercial seeds, as well as the simpler means for testing their purity and germinating power. The special investigation of clover seed grown in this country has been continued. The methods of handling and growing seed have been carefully studied, and a report on this subject will be published at an early date, which it is hoped will materially assist the producers of this seed, the demand for which is steadily growing abroad. Seeds purchased by the Department of Agriculture for distribution during the fiscal year 1895 were all submitted to purity and germination tests, but as the number of these seeds was very great few of them could be finished before the seeds had to be sent out. Many of the varieties showed a surprisingly low percentage of germination, and evidences of fraud were detected.

The work upon grasses and forage plants has been separated from the Division of Botany and has been placed in charge of a new division called the Division of Agrostology, which will be spoken of in another place.

The work on poisonous plants has been continued by a careful study

of laurel poisoning and the Western leatherwood, and a number of medicinal plants have been taken up for investigation.

AGROSTOLOGY.

In accordance with the recommendations of the Secretary of Agriculture in his report for 1894, the act making appropriations for the Department for the fiscal year ending June 30, 1896, contained a special provision for the Division of Agrostology. This division was organized July 1, when the act providing for its establishment went into effect, with Prof. F. Lamson-Scribner as its chief. The work of this division is devoted to the investigation of grasses and forage plants and experiments in the culture of our native species, as well as those of other countries which may be profitably introduced into the United States. These plants will be studied both scientifically and economically. The nature and the distribution of the various kinds will be considered, as well as their economic value and adaptability to special uses or to various soils and climates. The chief aim of the division will be to instruct and familiarize the people with the habits and uses of all forage plants by the publication of circulars, bulletins, and reports. The importance of this work is attested by the vast interests of our country which are dependent upon the products of our meadows and pastures.

EXPERIMENTAL GRASS STATIONS.

Two experimental grass stations have already been established for the purpose of enabling this division to effectively prosecute special lines of work in the cultivation of the several kinds and to bring under direct and intelligent observation the numerous native and cultivated grasses and forage plants. These gardens afford opportunity for the proper investigation of the nature and peculiar habits of growth of these plants, and to determine in a large degree their actual or probable value to agriculture. About 400 different varieties have been grown upon these gardens during the present season, and some of the native sorts tried have proved of interest. The true buffalo grass of the Western plains is one of these. Its cultivation in the grass garden has been a marked success, the grass forming in a comparatively short period a dense and pleasing sod completely covering the plat assigned to it. As this grass is more hardy than the somewhat similar Bermuda grass of the South, it may possess no less value for the Middle and Western States than is claimed for the latter in more southern latitudes.

When domesticated it may prove of great value because of its ability to withstand drought and its superior nutrient qualities. It is intended that a larger area of ground shall be set aside for the enlargement and continuation of experiments in grass and forage-plant culture, the results of which may prove of incalculable benefit to the farmers and stock growers of the United States.

SPECIAL STUDIES—PUBLICATIONS.

Special studies have been made of the grasses and forage plants of the Rocky Mountain regions and of the prairie regions of Iowa, Kansas, Nebraska, and the Dakotas, with a view to preparing a report upon the actual and prospective forage conditions of these sections of our country. A preliminary report has been published, giving the results of the examination of the grasses and forage plants of the Southeastern States, and circulars have been issued upon Hungarian brome grass, flat pea, sachaline, experimental grass gardens, and a Farmers' Bulletin on alfalfa, or lucern; other papers of a similar nature are in course of preparation, also an illustrated handbook of all the grasses of the United States.

HAY AND FODDER PLANTS—MONEY VALUE.

Each year develops more intelligent interest and inquiry in the production of better hay and fodder plants. The money value of the hay crop for 1894 was estimated at nearly a half billion of dollars. With more intelligent selection of hay plants cultivated the average production might have been 2 tons per acre, instead of 1.14 tons. That would have added 41,396,483 tons to the total crop of the year, and increased its cash value, based upon the low average price of $8.54 per ton for 1894, by $353,575,090.

The hay crop in the United Kingdom of Great Britain was a disastrous failure in the year 1893. As a consequence, the United States sold to the British during that year 124,390 tons of hay, while during the year 1895 we have exported to that country only 28,056 tons. On October 15 of this year prices of hay in London were $12 to $20 a ton. Though a superior article from the United States or Canada was sold upon that date at about $20 a ton, it is not expected that this price will encourage exports from this country, where the 1895 crop is below an average.

VEGETABLE PATHOLOGY.

The work of this division, of which Prof. B. T. Galloway is chief, has been broadened during the year to include plant physiology. It is believed that this will add materially to the value of the investigations. Owing to the crowded condition of the main building and the need of necessary facilities for work, new quarters were secured for the division early in February. The buildings now occupied are situated only a short distance from the Department proper, and are provided with necessary facilities for laboratory investigations. A greenhouse for conducting experimental work has also been provided. This adds greatly to the opportunities for work, especially in matters of interest to florists, market gardeners, and all others engaged in intensive agriculture. Work commenced last year on wilt diseases, which affect the potato, tomato, eggplant, and cotton in the South, and it is progressing satisfactorily. Experiments carried on in the field,

laboratory, and greenhouse have thrown much light on the causes of the diseases and the best methods of preventing them.

It is most pleasing to announce that the work on pear blight, which has been under way for some time, has evolved a thorough knowledge of the organism which causes that disease, and also in the discovery of a means to easily and cheaply prevent it. A bulletin on the subject is in the course of preparation, and will soon be ready for distribution.

During the year over one thousand varieties of wheats were tested by the division; the object sought being to discover their respective values in the matter of resisting rust and in their milling qualities. Crosses have been made with some of the more promising forms. They will be given a further trial and on a more extended scale.

The work on citrus diseases has been continued with very satisfactory results. Remedies and preventives for a number of the most serious have been found, and these findings will soon appear in a bulletin.

On the Pacific Coast, diseases affecting the peach, almond, apricot, apple, and grape have been studied. A successful method for the prevention of peach-leaf curl has been discovered, and a detailed account thereof will soon be published.

The complete and instructive exhibit of the division at the Atlanta International and Cotton States Exposition will, it is believed, be very useful to farmers, fruit growers, and others. In this exhibit the diseases affecting cotton, citrus fruits, and other crops of special interest to the South, are made a special feature.

POMOLOGY.

This division has continued, under the direction of its chief, Mr. S. B. Heiges, the systematic examination and comparison of supposed new varieties of fruits sent to it for identification, and has prepared careful studies and descriptions of the new specimens, illustrating them in most cases either with water-color sketches or colored models. These descriptions are carefully filed and must in time prove of great value. They will eventually make it possible to publish an authoritative work on the fruits of the United States.

The introduction and distribution of new varieties of fruits have been continued, the effort, however, being confined to the comparatively few varieties of fruits of great value not at present found in our country, but promising to do well here. Cions of many of these have been placed with experiment stations and sent to private experimenters for the purpose of determining their adaptability to various sections.

NEW VARIETIES OF FRUITS INTRODUCED.

Among the more important varieties that have been introduced are 65 new specimens of figs received from the Royal Horticultural Society

of England. For the present these varieties are being propagated in different places for the purpose of testing further their adaptability to our climate and soils and for producing a larger number of cuttings for distribution. It is believed that there is a large area of country within the United States adapted to the growth of figs and that it will be sufficient to supply our entire demand for this delicious fruit.

Other important importations consisted of 29 varieties of the choicest apples of Austria-Hungary, which have been grafted upon seedling stocks for the purpose of propagation. It is proposed to distribute these trees to the experiment stations as soon as they are in proper condition. Efforts have also been made to introduce improved and hardy varieties of persimmons from northern China and the citron of commerce from Italy.

EXPERIMENTS IN ROOT-GRAFTING APPLE TREES.

Considerable experimental work has also been undertaken. Prominent among these tests are experiments made with full-rooted and top-cut and lower-cut grafting in the propagation of apple trees. These experiments will be continued, and possibly on a larger scale. It is intended that trees grown from grafts as above described be distributed in different States and localities for testing. Varieties varying in habits of growth and longevity will be chosen. Generally they will be of standard varieties, like the Winesap, Albemarle, Pippin, Ben Davis, Oldenburg, Jonathan, and Northern Spy. Under this system of experimentation a few years will demonstrate whether whole roots, top cuts, or bottom cuts for grafting cions upon are most conducive to vigor of growth and longevity.

Special effort is being made to interest the State experiment stations in these and similar subjects and to secure their assistance in collecting new and comparatively unknown varieties of fruits. It is desired to develop some regular plan of cooperation by which the horticulturists of these stations shall collect new seedling varieties or other novelties and forward them to this division for identification, description, illustration, and preservation. Some central record office of this kind is absolutely necessary, and should be located in the Department of Agriculture.

FRUIT IN COMMERCE.

EXPORTS OF APPLES.

The economic value of apples for export is becoming more generally known to the horticulturists and farmers of the United States. Each year their exportation to Europe increases in quantity, quality, and value. Good winter apples, carefully selected and properly packed, always meet with a favorable reception and command good prices in Great Britain and on the Continent. Among the best known of American varieties on the other side of the water are the Baldwins, King

of Tompkins County, Ribston Pippins, Northern Spy, and various russets. But there is no doubt that the Winesap, Jonathan, Greening, Ben Davis, and Vandever Pippin, together with many other well-known varieties from the orchards of the United States, would be very acceptable and always secure for their shippers fair prices and profits. The most successful shipments of apples are made in New York barrels, which carry about 3 bushels and weigh about 112 pounds. The freight upon each of these barrels from American to European ports averages less than a dollar. During the fiscal year ended June 30, 1895, we shipped 818,711 barrels of apples abroad, valued at $1,954,318.

The following table shows our exports of apples, green or ripe, and dried, for the fiscal years ended June 30, 1893, 1894, and 1895, and the three months ended September, 1895:

Year.	Green or ripe.		Dried.	
	Barrels.	Value.	Pounds.	Value.
1893	408,014	$1,097,967	7,966,819	$482,085
1894	78,580	242,617	2,846,645	168,054
1895	818,711	1,954,318	7,085,946	461,214
Three months ended September, 1895	31,093	74,127	1,387,842	69,427

Export shipments of apples from any of the States east of the Rocky Mountains can be made remunerative. The apple among fruits is as staple and universally demanded as beef among meats. The variety which has sold for the highest price in British markets is the Albemarle Pippin, which is successfully grown to its greatest perfection in the State of Virginia. This variety has at times netted the growers $7 a barrel in the orchards. It is a remarkably fine keeper, of delicious flavor and beautiful coloring. The profits of intelligent horticulture along the Atlantic Seaboard can not well be overestimated. The success in foreign marts of the Pacific States fruit growers and shippers, laboring under the disadvantage of a rail carriage from the Pacific to the Atlantic, should stimulate all horticulturists this side of the Rocky Mountains to further secure sales for their products in Europe. The peaches of Delaware, Maryland, and most of the Southern States along the Atlantic Coast would certainly reach the London market in as good condition, if properly put up, as those from California.

CALIFORNIA FRUITS IN ENGLISH MARKETS.

California fruits have made marked gains in European markets during the last year. This trade began three years ago by a shipment on the White Star Line, which consisted of pears, peaches, plums, and grapes. The sale of that invoice at Covent Garden Market attracted public attention at the time, and the prices were so remunerative as to encourage further shipments. The succeeding year, however,

satisfactory terms could not be made for railroad and steamship transportation; consequently no shipments of California fruits were made during those twelve months to transatlantic markets.

But in the year 1894 the American Steamship Company carried over quite a number of fruit invoices. The results were satisfactory generally as to prices and profits upon the pears and peaches, while the traffic in grapes was not such as to induce further shipments of that fruit from the Pacific Coast.

A representative of the Department of Agriculture during the past summer attended the California fruit sales at Covent Garden. From that attendance he concludes that the California Fruit Transportation Company has solved the freight problem and that only the finest quality of fruit can be remuneratively sent abroad; even then sound condition and careful packing, and their arrival at London between the 1st day of July and the last day of August, can alone secure the best prices in competition with English and continental growers.

During the year 1895 the first lot of California fruit arrived in London on the 1st day of July. It met competing fruits from southern France, the Channel Islands, and Spain, together with fair specimens of English products, in a very propitious season. On that date fine English hothouse peaches sold at 15 cents each, with fair to common qualities at 5 to 3 cents each. All of the California fruit arriving on the date mentioned above consisted of Bartlett pears (in England called the Williams pear) and of peaches. They arrived in fine condition; the Bartletts brought from \$5 to \$6.25 per box of 50 pounds, and the peaches sold at an average of \$2.50 per box of 25 pounds. The pears retailed at from 4 to 5 cents each, and the peaches at from 6 to 12 cents.

The second arrival in the same market of California fruit was July 15. At this date the pears brought from \$3 to \$3.50 per box of 50 pounds, and the peaches and plums from \$1.70 to \$2 per box of 25 pounds.

The third arrival was on August 1, when the peaches and pears commanded about the same prices as in the previous shipments to the same market.

The fourth California fruit invoice was received in London the middle of August. It was an unusually large consignment and consisted of 10 carloads. Pears in this lot, in perfect condition, sold as high as \$2.80 per box. The peaches brought only \$1 to \$1.50 per box.

The fifth shipment of Pacific Slope fruit arrived in England on the last day of August. The late peaches were in very fine condition and gave the best satisfaction to dealers, but the prices were not as good as expected, as they ranged from \$1.20 to \$1.80 a box, according to quality. The pears ran from \$1.50 to \$3 per box.

The sixth shipment reached London in the month of September, via Southampton, where it was unloaded from the steamer *Paris* on Wednesday night and placed on sale in Covent Garden Market on

Friday morning. Buyers were eager to get hold of the late pears. They were in great demand, because of the satisfaction which the fruit of the two previous shipments had given. A large number of intending buyers were gathered about the auctioneer. The liveliest interest was displayed. The fruits were divided into lots representing different growers, one kind of fruit in each assortment. The boxes, made of the lightest possible durable material, were labeled with the names of the respective packers. The peach boxes contained 25 pounds. Each peach was wrapped in white paper, single thickness, a little heavier and tougher than tissue paper. The plums, not wrapped singly, were in similar boxes divided into small compartments. The pears were in 50-pound boxes and separately wrapped, though pears in 25-pound boxes bring a much better price. Under this system of selling, the reputation of some growers commanded special interest and higher prices from buyers. Those who desire to maintain á high standard of excellence, and decline under any temptation to send inferior fruits, and who use the most scrupulous care in packing, find their reward at last in a reputation which commands *enhanced prices for their products.*

The average quality of the peaches at this sale was very good. The Orange Clings seemed to be a favorite, while the late Crawfords in fairly good condition and Strawberry peaches did not seem to stand the transportation as well. The fruits from the hill counties of California were in firmer and better condition than those from the valleys.

Among pears, the Beurre Clairgeau and Hardys arrived in excellent order, and brought prime prices, while some Bon Chrétiens were also highly appreciated.

For a new branch of international commerce—one requiring great care and perfection in shipments—the exportation of California fruits to London has been quite as successful as could have been expected. The business is in its infancy, and has, if properly managed, a profitable future. Shippers must remember that there is always a market in London for such luxuries; that no fruit should be sent there except when in perfect condition and properly packed, and that, generally, prices will be more remunerative for early fruits. However, shipments were to arrive in London in September and October of this year, and it is possible that they will show better prices than some of the others, because they will meet with less competition from English and French and other continental fruits.

Fruit growers on the Pacific Coast, however, have special opportunities open to them in foreign markets for dried fruits, prunes, and raisins, and for brandies and wines. These particular industries need only be cultivated with energy and intelligence to achieve great results, and their development is earnestly commended to growers in that section.

ENTOMOLOGY.

The work of this division, of which Mr. L. O. Howard is chief, is grouped under the following heads: Investigations upon special insects; experiments with insecticides and insecticide machinery; determination of insects sent in by agricultural experiment stations and others and giving advice with regard to them; abstracting and cataloguing the literature of insects; scientific work upon groups of insects which have a bearing upon agriculture; special investigations. It will only be possible to mention here a few of the many valuable services rendered by this division.

THE MEXICAN COTTON-BOLL WEEVIL.

A new insect (*Anthonomus grandis*) which appeared in the cotton fields of south Texas, damaging the squares and bolls and ruining both fiber and seed, received especial attention during the year. The insect was found to be a species which had been brought across from Mexico, and so was commonly called the Mexican cotton-boll weevil. Through an agent sent into southwest Texas and into Mexico to study the history of this insect a careful investigation of the subject was made and a preliminary report has been published for the purpose of giving the people of this section proper warning. A complete report will be published during the coming winter. It is now hoped that the early fears as to the possible spread of the species throughout the entire cotton belt of the United States will not be realized, and that a tolerably efficient remedy for the prevention of the spread of the insect in south Texas has already been ascertained.

THE SAN JOSE SCALE.

Special efforts have been made to ascertain the exact points in the Southern States at which the San Jose, or pernicious, scale of fruit trees had established itself, and extensive experiments have been carried on for the purpose of ascertaining the best methods of combating this very destructive insect. Some progress has been made, and a bulletin on the subject will be published at an early day. In connection with this investigation, new studies have been made of all the principal scale insects of the orchard.

The edition of the report published ten years ago on insects affecting the orange having been exhausted, a new report on this subject has been ordered and is now rapidly approaching completion. This report will include consideration of all insects which affect citrus plants in other parts of the world than the United States, as they are all liable to be introduced into our country.

APPEARANCE OF INSECT PESTS.

Research has been made to determine the geographic distribution of injurious insects appearing in devastating numbers. The localities in

which they have appeared have been platted and the records of their damages carefully collated. With such data in hand, the entomologist will be able to predict the geographic lines at which the progress of certain species will stop and to advise agriculturists with some degree of certainty as to the possibility of the appearance of well-known insect pests in any given locality. The minor subjects of investigation have been insects injurious to shade trees, local outbreaks of the American and other locusts in different parts of the country, the cotton or melon plant louse, the currant-stem girdler, etc.

The work of this division in bee culture has been concluded with the completion of the manual on apiculture, which is now going through the press.

Experiments with insecticides and insecticide machinery cover such subjects as the effect of different arsenical poisons upon insects and upon the foliage and other parts of plants, the use of hydrocyanic acid gas against insects, new devices for spraying, etc.

Since the new insects which sprung into prominence as destructive species have to be classified, described, and named before they can be intelligently considered in popular publications, several competent assistants are preparing monographs on groups of such insects.

ORNITHOLOGY AND MAMMALOGY.

The name of this division is unfortunate, as it conveys an erroneous idea of the nature of its work. The division, of which Dr. C. Hart Merriam is chief, is in effect a biological survey, and should be so named, for its principal occupation is the preparation of large scale maps of North America, showing the boundaries of the different faunas and floras, or life areas. In fact, Congress, in 1890, authorized this division to undertake a comprehensive investigation of the geographic distribution of animals and plants; thus in effect establishing a biological survey. These maps when completed will show the farmer and fruit grower the areas on which particular kinds of grasses, grains, vegetables, and fruits may and may not be cultivated with success; thus saving the large sums of money now expended annually in futile efforts to make crops grow in places climatically unsuited to their needs. They will be further useful in indicating the areas subject to and those exempt from the ravages of destructive insects and other pests, and also those in which certain diseases of plants and animals are likely to flourish.

Within the Department these maps are helpful in many ways, serving as an intelligent basis for that part of the work of the divisions of Forestry, Botany, Agrostology, Pomology, Entomology, Vegetable Pathology, and Bureau of Animal Industry which relates to the geographic distribution of the forms they study.

In the preparation of faunal maps three kinds of work are necessary: (1) Field work, in collecting specimens and tracing the actual

limits of distribution by running lines across the country; (2) office work, in platting on maps the results of the field work; and (3) laboratory work, in determining the status of animals in groups that have not been worked up; for it is obviously impossible to map the distribution of a species which has not been discriminated from related species that may inhabit adjacent areas.

So far as preliminary work is concerned the biological survey has been already extended over the greater part of the United States except eastern Oregon, north and central Nevada, parts of New Mexico and Texas, and some of the Eastern States. In addition, a detailed survey has been made, with a degree of accuracy equal to or exceeding that of the best topographic maps available, of large parts of California, western Oregon and Washington, Idaho, Montana, Wyoming, South Dakota, Utah, Arizona, and a number of the Southern States.

Of all the life zones entering the United States, the Austral, which covers the southern tier of States and much of California, is of greatest importance, because of the large number of specially valuable crops—as cotton, rice, sugar cane, the citrus fruits, raisin grape, fig, olive, and almond—that grow within it. The northern boundary of both arid and humid divisions of this zone have been followed completely across the continent and shown on maps prepared by the division. The final maps of the life zones, when available to the intelligent farmer and fruit grower, are likely to save the country each year far more than the total cost of maintaining the division.

The more strictly economic work relates to the food habits of our native birds and mammals. These are studied in the field and their stomachs are examined in the laboratory in order to ascertain the normal food of the different species. In this way the beneficial kinds are known from the injurious, and the results are published in special bulletins. Those thus far issued treat of the English sparrow, crow, crow-blackbird, woodpeckers, hawks, and owls, pocket gophers, and ground squirrels.

AGRICULTURAL SOILS.

This division, which was organized eighteen months ago as a division of the Weather Bureau, with Prof. Milton Whitney as chief, has now been taken out of that Bureau in accordance with the recommendation of the Secretary of Agriculture and the act of the last Congress and given an independent organization. As also provided in the appropriation act, it is now accommodated in a building convenient to the Department, which was rented and rearranged for its special use.

ADVANTAGES OF SUBSOILING.

While the Division of Chemistry has been making a study of the chemical properties of soils and of the bacteria which prepare nitrogen for plants, this division has been investigating the physical and

The office has published directions for building improved roads, compilation of road laws, information regarding road material and transportation rates for the same, the proceedings of road conventions, and much other useful information for free distribution among the people.

It is proposed during the coming year to secure the cooperation of agricultural colleges and experiment stations in the object-lesson method of disseminating this information. They will be taught to construct model roads on the farms of their experiment stations or on their college grounds, where they can be regularly used, and thus become a lesson to all the farmers who visit them.

Public interest in the whole subject of road improvement has become thoroughly aroused, and a feeling of great hopefulness has been developed. The usefulness of a central good-roads propaganda such as this office affords has been amply illustrated.

FIBER INVESTIGATIONS.

The decline of the price of cotton and the successful establishment in this country of ramie manufacturing has called increased attention to the cultivation of this plant. Correspondence with reference to it has been very large, and has necessitated the publication of a special report on the subject in addition to the paper in the last Yearbook. The great desideratum is still a practical ramie decorticating machine. Recognizing this, the Department has endeavored, in the line of its duty, to assist by study and suggestions in perfecting practical apparatus for this purpose. In cooperation with the Louisiana experiment station it has tested a number of new machines. These trials showed gratifying progress in their construction, and though they have not yet produced a perfect machine, it is confidently believed that American inventors will at last successfully solve this problem.

Experiments in the production of flax in the region of Puget Sound, Washington, have been continued during the year on a larger and more comprehensive scale with the cooperation of farmers in several sections of the State. Some very fine samples of straw have been submitted, which encourages a hope for satisfactory final results. The interest in the profitable growth of flax has been much stimulated in this region. In evidence, it is said that a considerable area will be planted with this crop next season. In furtherance of this interest, a Farmers' Bulletin was published on "Flax for Seed and Fiber," which has been successfully circulated with good results in sections interested.

Other fibers which have been subject to more or less inquiry are sisal hemp, pineapple fiber, jute, and the common hemp of the North.

A descriptive catalogue of the world's fibers is in preparation by Mr. Charles Richards Dodge, the special agent in charge of this work.

MICROSCOPY.

The Division of Microscopy was established in the Department of Agriculture twenty years ago, when this art was considered a separate branch of technology. Since that time the microscope has come into daily, almost hourly, use in nearly all scientific laboratories. A separate Division of Microscopy in this Department has thus become an absurdity. The Department of Agriculture during the last fiscal year used at least 500 microscopists of one class or another outside of the Division of Microscopy to the one in it. This division, having completed a line of investigations on edible fungi, the butter fats used for adulterating purposes, the textile fibers, and one or two other subjects which it had undertaken some years ago, was abolished on the 1st of July, 1895. The apparatus and material pertaining to fungi were turned over to the Division of Vegetable Pathology, which makes a special study of fungi and fungous diseases of plants; the material pertaining to food adulterations was turned over to the Division of Chemistry, which by law is charged with the investigation of this subject; and the material belonging to textile fibers was turned over to the Office of Fiber Investigations. These divisions will continue to attend to any investigations needed under these heads.

PUBLICATIONS.

The Division of Publications is in charge of Mr. George William Hill, who has managed and directed its affairs from the day of its inception. During the fiscal year, under his vigilant supervision, 254 publications have been issued, including 120 reprints. The total number of copies of bulletins, pamphlets, and other publications aggregates more than 4,000,000. Together they make 420,000,000 printed pages, each page containing more than 500 words. Thus the Department of Agriculture has issued in a single year, gratuitously and promiscuously, under present laws, more than six printed pages for every man, woman, and child in the United States. This vast volume of reading matter, given free of cost to all who asked for it and mailed postage free to the donees wherever they might be, caused the disbursement of a large sum of public money for paper and printing alone. The regular annual report, averaging nearly 40 ounces per volume, made more than 600 tons weight for gratuitous delivery in the various States and Territories by the Post-Office Department.

A careful comparative estimate shows that the total weight of publications, other than the annual report, aggregated 200 tons. Thus this Department alone has given 800 tons weight to the postal authorities for gratuitous transportation.

GRATUITOUS DISTRIBUTION CONDEMNED.

In view of the above facts it is again recommended that all publications issued by the Department be furnished to such citizens only as will pay for their net cost and added postage, and that gratuitous

distribution be confined to public libraries and benevolent and educational institutions, with the exception of such publications as may be for specific purposes and properly termed "exigency" or "emergency" documents. Under the present system many secure publications who do not need them for practical purposes, and those who would put them to good use are frequently unable to get them because editions have been exhausted by the former class. To-day almost any Government publication, no matter when it was published or how rare or valuable it may have become, can be purchased in second-hand and other book stores in nearly all the larger cities of the country. There is not time to detail here the extravagance and needlessness of the present system. At this writing the Department has knowledge of the sale of the Yearbook issued in September by booksellers, and learns of the proposed sale of the same in large lots at $5 per 100. It is enough to suggest that the annual deficiencies of the Post-Office Department are largely attributable to this unwise distribution. With great satisfaction reference is made and public attention called to the report of the chief of this division.

SEED DIVISION.

Under the direction of Mr. M. E. Fagan, chief of the Seed Division, there were gratuitously and promiscuously distributed during the last fiscal year, in accordance with a long-prevailing practice, about 10,000,000 papers of flower and vegetable seeds. His report, together with that of Enos S. Harnden, the authorized purchasing agent of seed for the Department, is submitted and published. Together they give a detailed account of the purchase and distribution of the seed, which involved the deadheading in the United States mails of 270 tons weight.

After the adjournment of the Fifty-third Congress inquiry was made at the Department of Justice as to the legality of purchasing any other than seeds "rare and uncommon to the country," etc. The following letter from the honorable the Attorney-General of the United States answered and settled the question:

DEPARTMENT OF JUSTICE,
Washington, D. C., April 20, 1895.

The SECRETARY OF AGRICULTURE.

SIR: I have the honor to acknowledge yours of the 18th instant, in which you call my attention to a portion of the act making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1896, and approved March 2, 1895, and running as follows: "*Division of Seeds—Purchase and distribution of valuable seeds, and for the printing, publication, and distribution of Farmers' Bulletins:* For the purchase, propagation, and distribution, *as required by law*, of valuable seeds, bulbs, trees, shrubs, vines, cuttings, etc., one hundred and eighty thousand dollars."

You make two inquiries, as follows:

"Can the Secretary of Agriculture legally purchase any other seeds than those described in section 527 of the Revised Statutes, to wit, seeds 'rare and uncommon

to the country, or such as can be made more profitable by frequent changes from one part of our own country to another,' under authority of the act of March 2, 1895?

"Would it be proper and lawful for the Secretary of Agriculture, in view of the verbiage of the act of March 2, 1895, and the wording of section 527 of the Revised Statutes, to advertise for proposals to furnish the Department of Agriculture seeds, bulbs, trees, vines, cuttings, and plants 'rare and uncommon to the country, or such as can be made more profitable by frequent changes from one part of our own country to another,' reserving the right to reject any and all bids?"

1. The seeds purchasable under the act of March 2, 1895, are limited to those described in section 527 of the Revised Statutes—there being no reasonable ground for claiming that the act of March 2, 1895, operates, or was intended to operate, as a repeal of the earlier statute.

2. If not obligatory upon the Secretary of Agriculture to purchase seeds, trees, etc., conformably to section 3709 of the Revised Statutes, it is certainly competent for him to make the purchases conformably to said statute, the right to reject any and all bids being reserved. But the form of the question is such that I think it proper to call attention to the fact that while seeds purchased must be such as are "rare and uncommon to the country, or such as can be made more profitable by frequent changes from one part of our own country to another," the trees, plants, shrubs, vines, and cuttings to be purchased are such "as are adapted to general cultivation and to promote the general interests of horticulture and agriculture throughout the United States."

Respectfully, yours, RICHARD OLNEY, *Attorney-General.*

And the following advertisement was immediately inserted in the legally required number of newspapers:

PROPOSALS.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., April 27, 1895.

In accordance with section 527 of the Revised Statutes, which authorizes the purchase of "seeds rare and uncommon to the country, or such as can be made more profitable by frequent changes from one part of our own country to another," also "such trees, plants, shrubs, vines, and cuttings as are adapted to general cultivation, and to promote the general interests of horticulture and agriculture throughout the United States," and in accordance with the terms of the appropriation (act approved March 2, 1895) for the purchase and distribution of valuable seeds, "as required by law," sealed proposals, in duplicate, subject to the usual conditions, will be received by the Secretary of Agriculture until 2 p.m., July 1, 1895, for supplying to the United States Department of Agriculture during the fiscal year ending June 30, 1896, and to be delivered before November 1, 1895, such valuable seeds, trees, plants, shrubs, vines, and cuttings as are covered by section 527 of the Revised Statutes quoted above. Persons submitting bids should specify the kind and varieties, with full description of each variety, of seeds and plants upon which they desire to submit bids and the quantities they are prepared to contract for, and must guarantee delivery of the same in Washington. The right is reserved to reject any or all bids.

J. STERLING MORTON, *Secretary.*

There were only three bids made under the above, and they were passed upon and rejected by a committee, as follows:

WASHINGTON, D. C., *July 6, 1895.*

The SECRETARY OF AGRICULTURE.

SIR: The undersigned board, appointed by you on July 1, 1895, to open and examine bids for seeds to be furnished this Department for distribution according

to law, during the fiscal year ending July 1, 1896, have the honor to report that we have opened and examined the bids received and find that the same do not meet the requirements of the advertisement as printed, and therefore respectfully recommend that all bids be rejected.

Respectfully, yours,

ENOS S. HARNDEN.
F. L. EVANS.
J. B. BENNETT.

The various divisions of the Department had been for a long time crowded for want of proper office rooms. Therefore the first story of the large building heretofore mostly occupied by the Seed Division was at once, under the law providing for such emergencies, speedily transformed into apartments for the Division of Entomology and the Division of Ornithology and Mammalogy, and immediately occupied by the chiefs and clerks thereof. In this way the library room of the main building of the Department has been relieved from a congestion of accumulated specimens, books, and other property which heretofore lumbered up the galleries of that room in various unsightly pine-board partitions. The two divisions named have, for the first time since their existence, been properly housed and decently provided with working rooms suitable to their peculiar labors and lines of investigation.

The detailed showings of the chief of this division, and likewise of the seed-purchasing agent, will, in all probability, sufficiently enlighten the general public as to the needlessness and folly of the annual gratuitous and promiscuous distribution of seeds deadheaded through the United States mails.

The one hundred and thirty thousand dollars appropriated by the Fifty-third Congress for the purchase and distribution of seed this year is practically intact, and consequently undrawn from the Treasury of the United States.

GARDENS AND GROUNDS.

The gardens and grounds of the Department are, as they have been for more than thirty years, in charge of the chief of that division, Mr. William Saunders, horticulturist. The work of the division has consisted "in keeping the grounds in good condition, in the cultivation and care of the plant and fruit houses, and in the propagation of plants for home use and for distribution."

The free and promiscuous distribution of strawberry and grape vines, privet plants, camphor trees, tea trees, olive trees, fig trees, pineapples, and miscellaneous varieties of cuttings ought to be abolished. But if the propagation of rare and valuable plants, vines, and exotics is to be continued by the Department, the distribution should be limited to the experiment stations and agricultural farms of the several States and Territories. By such a limitation the appropriation for this division could be very materially reduced. It is, however, the purpose of experiment stations and agricultural colleges to attend to the introduction of new, rare, valuable, or improved plants,

vines, and seeds to their respective localities. Those institutions are in charge of and directed by skilled, scientific agriculturists of great experience. Therefore all of this business of propagating and distributing new varieties should be relegated to those institutions. Before their existence there might have been some excuse for the gratuitous and promiscuous distribution of seeds, vines, plants, trees, and cuttings, but there is *no* necessity for such distribution at this time at the expense of the Federal Treasury. That being the case, the appropriation for the care of thirty-five acres of grounds about the United States Department of Agriculture and for the greenhouses thereon situated could be very materially and profitably reduced.

ACCOUNTS AND DISBURSEMENTS.

Chief F. L. Evans has submitted a summary of the work of this division for the fiscal year ended June 30, 1895, together with a statement of appropriations, disbursements, and unexpended balances of the United States Bureau and Department of Agriculture from the fiscal year 1839 to and including the fiscal year 1895. His report is entirely satisfactory and could only be evolved from a service of great perfection over which he has with scrupulous economy and vigilance most efficiently presided.

The appropriation for the maintenance of this Department for the year 1895 was one hundred and four thousand four hundred and seventy-six dollars and ninety-four cents ($104,476.94) less than the appropriation for 1895, and yet it was one hundred and eighty-three housand four hundred and twenty dollars ($183,420) more than the amount estimated for by the Department.

For the fiscal year ended June 30, 1893, there was covered back into the Treasury of the United States from the appropriation for this Department one hundred and eighty-five thousand four hundred and ninety-seven dollars and sixty-four cents ($185,497.64). Subsequently the sum of (in round numbers) six hundred and twenty-five thousand dollars ($625,000) for the fiscal year 1894 was returned to the Treasury, and for the fiscal year ended June 30, 1895, there is an unexpended balance amounting to about five hundred thousand dollars ($500,000).

RECAPITULATION.

Five million one hundred and two thousand five hundred and twenty-three dollars and six cents ($5,102,523.06) was appropriated to the United States Department of Agriculture during the two fiscal years 1894 and 1895; and out of that sum one million one hundred and twenty-six thousand two hundred and sixty-eight dollars and seventy-four cents ($1,126,268.74) has been saved to cover back into the Treasury.

Then add to that saved sum the one hundred and eighty-five thousand four hundred and ninety-seven dollars and sixty-four cents ($185,497.64) returned to the Treasury out of the 1893 appropriation, and we find that, with an unimpaired and extended and disciplined

service in this Department, the aggregate sum of one million three hundred and eleven thousand seven hundred and sixty-six dollars and thirty-eight cents ($1,311,766.38) is available for return to the Treasury since March 4, 1893.

In a Government where vast sums are handled every day and tens and hundreds of millions of money are ordinary topics of conversation, the saving of thirteen hundred thousand dollars may attract little attention and less commendation. But in the most fertile farming county in the best agricultural sections of the American Union it will be difficult to find thirteen hundred farmers who all together have earned and saved as much in the same period of time. No other class of gainfully employed workers among the citizens of the United States are so interested in a judiciously economical management of governmental affairs as are the farmers, who directly and indirectly pay the most taxes in proportion to their property, because that property is, as a rule, material and visible. And farmers, more than any other class, ought to know that governments, whether monarchal, despotic, or democratic and republican, are born without money and never get any money except by taxing either subjects or citizens, and that a tax is *payment by the citizen to the Government for the protection it gives* to property, life, and liberty. And further, that neither bankers, railroad owners, manufacturers, farmers, nor any class, can legitimately demand the expenditure of public funds for any other purpose than that for which they were taken from the people.

BUILDINGS FOR THE DEPARTMENT OF AGRICULTURE.

It is suggested that the Weather Bureau could be furnished with commodious offices and apartments in the top story of the new post-office building in the city of Washington, and upon the roof of the same edifice the exposure of all the instruments used in taking meteorological observations could be advantageously made, while a small part of the basement of the same building set apart for the printing office and presses, whence the daily weather maps are issued, would complete a most desirable domicile for that Bureau.

Such a transfer having been made from its present location, the Weather Bureau buildings and grounds at the corner of Twenty-fourth and M streets, in the city of Washington, could be converted into cash and would bring something like $200,000 or $300,000. This sum, added to the $1,300,000 which has been saved and covered into the Treasury from appropriations for the Department of Agriculture for the fiscal years 1893, 1894, and 1895, makes $1,500,000, which, invested in a building constructed purposely for the Department of Agriculture, would afford in compact form sufficient accommodations for every one of the divisions and bureaus and bring them in daily communication with each other. Under the present system of renting (rents now amounting for this Department to $3,920 a year) the expenses are increasing, and the necessity of having all the divisions and bureaus, especially those of a scientific character, brought together is becoming more and more obvious.

In view of these facts, if the Department of Agriculture is to be domiciled, as every other Department is, in a building proportioned to the value and magnitude of the interests which it conserves, it is suggested that an appropriation for the construction of an edifice for the Department of Agriculture must be made in the very near future.

EXTENSION OF THE CIVIL SERVICE.

By Presidential order, on May 24, 1895, all the employees of the Department of Agriculture, with the exception of three persons holding office by appointment of the President and of some 500 laborers and workmen (not skilled) and charwomen, were included in the regularly classified civil service. Of the 500, only 78 laborers are in Washington. Of employees included in the classified service only four are excepted from the rule requiring appointment by competitive examination or by promotion. That order, therefore, put all the educated and skilled force of specialists and scientists, including all the chiefs of division of this Department, into the classified service.

The total number of employees is 2,019. Four hundred and twenty-nine are females. One hundred and sixty-five out of the whole number were appointed after civil-service examination and certification. Thirty-three of this number are women.

From the date of the enactment of the civil-service law, January 16, 1883, to March 6, 1893, the number of persons appointed in this Department after examination and certification by the United States Civil Service Commission, under the rules, was 112. Of that number 42 were women.

But since March 7, 1893, the number so appointed has been 102. It lacks only 10 of being as many as had been appointed in accord with civil-service law and regulations during more than the ten previous years. And since March 7, 1893, only 8 women have been so appointed. Of the whole number of 214 thus brought into the service 49 persons have been severed from the Department by resignation, transfer, or otherwise. Of that total civil-service list 37—25 males and 12 females—have been severed from the service since March, 1893.

A thoroughly economical and efficient departmental service can only be secured and maintained by extending the provisions of the civil-service law so as eventually to include all purely nonpolitical ministerial officers, clerks, skilled workmen, and laborers. This is not the place to discuss in detail the amendments and modifications needed to render the civil service of this Government one of the most enlightened, prompt, and efficient in the world. The subject, however, justly claims space in this report for the expression of the conviction that the service of the Government should be put, in all respects, on as good a footing as that of first-class establishments conducting professional or commercial enterprises.

The present system, awarding unduly large salaries for the simplest clerical work, almost mechanical in its character, invites an influx to Washington of persons seeking work who properly belong to the

lowest clerical grade. But unfortunate statutory limitations restrict salaries for the more responsible and important positions, which require special knowledge, to a level 25 or 50 per cent lower than those paid for similar efforts by reputable commercial and professional establishments throughout the country. Radical reorganization is needed, therefore, in these respects. Reasonable remuneration in the subordinate ranks and sufficient inducements in the higher grades to stimulate ambition and suitably reward exceptional merit will, together with permanency of tenure and the responsible character of the employer, attract talent, industry, and character to the service of the Government. Under other conditions, which have been tried, favoritism, injustice, and dependence upon political influence saturate the service with mediocrity, indolence, and inefficiency.

Before dismissing this subject special attention is directed to section 25 of Chapter II in the Vermont constitution of 1793, which embodies on the subject of public officers and office holding in general a specimen of good New England sense which may be studied with advantage at the present time, more than one hundred years after its adoption:

> As every freeman, to preserve his independence, if without a sufficient estate, ought to have some profession, calling, trade, or farm, whereby he may honestly subsist, there can be no necessity for nor use in establishing offices of profit, the usual effects of which are dependence and servility, unbecoming freemen, in the possessors or expectants, and faction, contention, and discord among the people. But if any man is called into public service to the prejudice of his private affairs, he has a right to a reasonable compensation; and whenever an office, through increase of fees or otherwise, becomes so profitable as to occasion many to apply for it, the profits ought to be lessened by the legislature. And if any officer shall wittingly and willfully take greater fees than the law allows him, it shall ever after disqualify him from holding any office in this State until he shall be restored by act of legislation.

THE FUTURE OF FARMS AND FARMING IN THE UNITED STATES.

The farms of the United States, averaging 137 acres each, are valued at more than $13,000,000,000. Those farms number four million five hundred and sixty-four thousand six hundred and forty-one[1] (4,564,641), and their average value in the census of 1890 is $2,909.

The farm family, including hired help, averages six persons. By their own labor, with an additional investment upon each farm of about $200 in implements and $800 more in domestic animals and sundries (making a total farm plant of $4,000), those families made for themselves during the year, out of the products of the earth, a wholesome and comfortable living.

The same farmers have with part of their surplus products also fed all the urban population of the United States, poor and rich alike. Cereals, meats, vegetables, fruits, eggs, milk, butter, cheese, and poultry have been supplied the village and city markets of the United States in abundance. It is probably safe to say that more than 40,000,000 of American citizens not living on farms have been so fur-

[1] The 1893 report of the Secretary of Agriculture erroneously stated the number of farms in the United States at 6,000,000.

nished with all the necessities and luxuries known as products of the varied soil and climate of the States and Territories of the Union.

During the fiscal year 1895 the United States exported to foreign countries domestic commodities, merchandise, and products aggregating in value $793,000,000. The aggregate value of the agricultural products included in that sum was $553,215,317. Of the total exports Europe received a valuation of $628,000,000, or 79 per cent of the whole.

Thus American agriculture, after feeding itself and all the towns, villages, and cities of the United States, has also sold in the outside world's markets more than $500,000,000 worth of products. So the farmers of the United States have furnished 69.68 per cent of the value of all the exports from their country during the year 1895.

But this large number of consumers, consisting not only of our own citizens, but of the citizens of all nations, have not been gratuitously fed, though their supplies have been constant and abundant. With sound money of the least fluctuating buying power—money on a parity with and convertible into gold the world over—American farmers have been remunerated for their products.

The exact amount paid for the products of agriculture consumed in the United States during the year is not known, but it must have aggregated hundreds of millions of dollars. But all products, i. e., those consumed at home and abroad, were in—

1870 (including betterments and addition to stock)	$2,447,538,658
1880	2,212,540,927
1890	2,460,107,454

No absolutely credible method of estimating products for 1895 is available at this time, but since production has not increased to any considerable extent, and the farm value of many of the chief products has decreased to a remarkable degree, it seems reasonable to assume a decrease in the total valuation of farm products since 1890. Say, as a rough approximation, the valuation is $2,300,000,000.

In the presence of these facts, in the front of these figures demonstrating that agriculture in this Republic has during the year fed itself, supplied all citizens of the Union engaged in other vocations, and then shipped abroad a surplus of over $500,000,000 worth of its products, how can anyone dare to assert that farming is generally unremunerative and unsatisfactory to those who intelligently follow it?

How can the 42 per cent of the population of the United States which feeds the other 58 per cent and then furnishes more than 69 per cent of all the exports of the whole people be making less profits in their vocation than those whom they feed when the latter supply less than 31 per cent of the exports of the country?

For the purpose of illustrative comparison transfer the $4,000 agriculturally invested in each farm of 137 acres to the choicest Wall street investment. Risk that money in railroad first-mortgage bonds, in bank stocks, or any other allegedly safe security which may be found a favorite among shylocks, brokers, plutocrats, monopolists, money-power manipulators, and multimillionaires, and if it returns

6 per cent it is a remarkably profitable investment in the eyes o capitalists. Therefore $240 is the annual income.

Follow the transfer of the farm money with that of the farm famil to urban residence. Now, with the same labor in the city or villag can they attain by hard work every day in the year, adding thei wages to the $240 income, as much of independence, wholesome living and real comfort as the same amount of money in the land and th same heads and hands working on the soil generously and healthfull bestowed upon them, in the sweet quiet of a home, amidst flowers trees, fruits, and abundance, on the farm?

But the declaimers of calamity declare that the farms of the Unite States are sadly burdened with mortgages. The census of 1890, how ever, develops the fact that on the entire valuation returned for farm there is only a mortgage of 16 per cent. It will be borne in mind, too that many thousands of acres of mortgaged lands of great value whicl are returned as farms were such only before they were mortgaged They were purchased to plat as additions to cities like Chicago, Brook lyn, Kansas City, and Omaha, and ceased to be farm lands as soon a mortgages representing part of the purchase price were recorded. Sucl lands are, therefore, wrongfully included and returned as farms. The show an aggregate of many millions of liabilities.

On each $10,000 of rural real estate there is, then, an average incum brance of $1,600. And when the fact is recalled to mind that a larg part of all farm mortgages is for deferred payments on the land itself or for improvements thereon, what other real or personal property in the United States can show lesser liabilities, fewer liens in proportio to its real cash-producing value? Certainly the manufacturing plant of this country, neither smelting works, mills, iron and steel furnace and foundries, nor any other line of industry, can show less incum brance on the capital invested.

Railroad mortgages represent 46 per cent of the entire estimate value of the lines in this country. On June 30, 1894, 192 railroad were in the hands of receivers; they represent $2,500,000,000 cap ital—nearly one-fourth of the total railway capitalization of th United States.

On that date how relatively small was the amount of money in farn mortgages compared to the value of the lands securing them?

During the year 1894, according to the five reports made that yea to the Comptroller of the Currency, the average indebtedness to thei depositors of the national banks was $1,685,756,062.45. Besides th above, State and private banks, loan and trust companies, and saving banks owed their depositors during the same period an average o $2,973,414,101, making a total of $4,659,170,163.45.

And in this year, 1895, by the responses of national banks to th four calls thus far made upon them by the Comptroller of the Cur rency, their aggregate indebtedness to depositors is shown to b $1,719,597,911.33; State and private banks, loan and trust companies, and savings banks show an aggregate indebtedness to their depositor of $3,185,245,810, making a total of $4,904,843,721.33.

These figures show an enormous and constant indebtedness of the banks and bankers alongside of which the money in farm mortgages and the debts owed by farmers are relatively insignificant. The debts of railroads, bankers, manufacturers, and merchants entitle them, and not the farmers, to be called the "debtor class" in America.

In 1880, 44 per cent of all Americans engaged in gainful occupations were in agricultural pursuits. Applying the same ratio to the total population we should have a farming population in the United States for 1880 of 22,068,434. The returns of the Eleventh Census show that the rural population has increased by 4,078,422 during the decade 1880-1890. Adding this to 22,068,434, we get a rough approximation of the farming population in 1890—26,146,856, or 42 per cent of the total—and the number of farms in the United States in 1890 being 4,564,641, the average number of persons on each farm would thus, approximately, be 6.

There were in 1890 improved farm lands in the United States representing an area of tilled and productive fields amounting to 357,616,755 acres. At that time the United States contained 65,000,000 people. Therefore, each citizen of the United States, with an equal per capita distribution of farm products, was entitled in the year 1890 to receive the cereals, vegetables, and other products evolved from 5½ acres of cultivated land, less the amount consumed for the maintenance of domestic animals. These figures illustrate the importance of having some other than an exclusive "home market." No legislation, however encouraging or protective, will be able to create an American demand, appetite, and digestion of sufficient magnitude to consume all that American farmers produce. Human beings capable of eating the food products of even 2½ acres each year have not yet been developed. Until they are or until the population of the United States has been quadrupled, foreign markets for farm products are essential to the prosperity of the plowmen and planters of this country.

It will be observed that between 1880 and 1890 the proportion of the people engaged in agriculture declined 2 per cent, and that to-day there are only 42 persons in rural pursuits to 58 in mercantile, manufacturing, and other callings common to the great populational and industrial centers. Fifty-eight per cent of the people can not always be satisfactorily maintained upon the profits of exchanges among themselves in the villages and cities. Food for all must come from the earth—from tilled fields. The population of the United States in 1915—a quarter of a century after the census of 1890—admitting that the increase will diminish very materially as compared with that of each preceding quarter of a century since the Government was established, will, no doubt, number at least 120,000,000.

The value of farm lands, being governed by the relation of the supply of those lands to the demand for them, will therefore steadily increase. The area or supply remains stationary, or from careless tillage decreases. But the added millions of our population augment and intensify demand. Therefore the prices of farms must in the next twenty years, and possibly in ten years, advance more markedly

than those of urban real estate. The owners of fertile fields, however, must understand now that agriculture is swiftly becoming a scientific profession. The more the farmer cultivates his mind the better and more profitably he can cultivate his fields. The Department of Agriculture has expended during each of the last two years a greater per cent of its appropriations in the application of science to farming, to correct tillage and fertilization, than ever before.

Each season teaches anew the imperative necessity of more and more scientific knowledge for those who are to plow and plant profitably. The markets of the world will finally be invaded, captured, and held by those who produce cereals and meats, vegetables and fruits at the least cost, and can therefore most cheaply sell. Competition is fiercer every year. American inventions, improved implements and machinery for saving labor on the farm and for saving the fruits of that labor are exported to Africa, Europe, and South and Central America. Thus our own recipes and contrivances for cheap production are used abroad to strengthen the abilities of foreign farmers to contend with our own in foreign markets. Information direct from Russia, from Argentina, and from Africa tells of larger sales of American agricultural implements and machinery annually in each country.

Thus competition is made far more formidable by the increased use in foreign parts of our own improved machines and implements with which American manufacturers more than ever are supplying them. In view of such a state of facts, farmers must, to be successful, study probable demand and adjust supply to its needs. Forecasts of markets and their conditions can, by diligent study and attention, be so accurately made as to nearly always secure producers against loss. The profits of planting must largely become premeditated. The struggle to obtain for the offerings of the American farmer the markets of the globe is fiercely carried on between him and every other farmer in all the world. They are brothers in agriculture, as were Abel and Cain, "bringing the fruits of the ground" for approval. He who brings the best and cheapest will find approval in welcoming purchasers and remunerative prices. The success of the farmer of the future therefore depends more upon mental than upon manual effort.

An act of Congress approved May 15, 1862, creates—

> A Department of Agriculture, the general designs and duties of which shall be to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word.

And the foregoing report, in conformity to the spirit and letter of that law and in accord with the educational design and scope of the Department, is respectfully submitted, with the belief that in it may be found "useful information connected with agriculture in the most general and comprehensive sense of that word."

J. STERLING MORTON,
Secretary.

DEPARTMENT OF AGRICULTURE,
Washington, D. C., November 15, 1895.

SOIL FERMENTS IMPORTANT IN AGRICULTURE.

By H. W. Wiley,
Chief of the Division of Chemistry, U. S. Department of Agriculture.

VITALITY OF THE SOIL.

Not many years ago the soil was regarded by the agriculturist as dead, inert matter, devoid of all vitality. The theories of fertilization of the soil were based upon this idea, and the methods of culture were conducted according to the same theory. The only vital thing which the farmer considered was the growing crop itself, and there was no suspicion of the relations existing between the vitality of the crop and the living organisms of the field. The reader of the agricultural literature of to-day does not need to be told how all this has been changed in the last twenty years. The soil is no longer regarded as dead and inert matter, but is known to be so permeated with living beings as to entitle it to be considered a living mass. The parts of the soil which are not endowed with life now receive their highest significance as the environment of the living organisms which they contain and which they may help to nourish. The plant which forms the growing crop receives its nourishment through the media of the air and soil, but this nourishment must undergo a process of digestion, before it becomes available as plant food, similar to that suffered by the food which nourishes animals. Indeed, the purely mineral, inorganic foods of plants are probably not always absorbed as such, and must undergo a decomposition before they are assimilated. A striking instance of this is shown in the case of silica, an important plant food and a type of inert mineral matter. Silica is highly insoluble and apparently the least suited of the mineral constituents of the earth to enter the vital organism of the plant. Yet not only do we find it in the tissues of the mature plant, but also, strange to say, in the greatest abundance in those parts of the plant organism, viz, the leaves, most remote from the sources of supply. It is evident from this that the highly insoluble silica of the soil must undergo a complete solution in order to be carried by the juices of the plant through the network of cellular tissues to be finally redeposited in the leaf.

The same statement may be made with regard to the other purely mineral foods of plants. It is quite certain that they do not become a part of the plant organism in the form in which they are found in the

however minute, can be bodily transported in a mechanical way and become an integral part of any plant tissue. Any attempt to move soil particles in this manner could only result in a clogging of the pores of the cellular tissues, the stoppage of the circulation, and consequent death of the plant. The mineral particle in question, therefore, must suffer a complete disintegration, and the only forces capable of effecting this, in so far as we know, are the solvent action of the plant secretions, the vital activity of the rootlet itself, and the decomposing influence of the soil ferments. What particular proportion of the solvent action is due to each of these causes has not yet been determined. It is known, however, that the weak organic acids which may be contained in secretions from the roots of plants are not capable of exercising a very important solvent influence on the soil particles.

In fact, one of the organic acids which may be found in the secretions of the rootlets of plants, viz, oxalic acid, is capable of exerting an influence which is unfavorable to the decomposition of mineral matters containing lime. A mineral which is composed in part of lime when exposed to the action of oxalic acid becomes coated with a film of lime oxalate which prevents any further decomposing action. The influence of nitric acid, which is due to the activity of soil ferments, is exerted in this case in the most beneficial way, attacking and dissolving the film of lime oxalate and exposing fresh portions of the mineral substance to decay. Phosphoric acid especially, which is so often found in combination with lime, may be released by this action and made available. It must not be forgotten also that lime itself is an essential plant food and must be supplied in appropriate quantities to secure a normal growth of the plants.

The "vital activity" of the rootlet itself, a phrase often used, has an indefinite meaning and conveys absolutely no comprehensible idea of solvent action. On the other hand, it is known that soil ferments are found in particularly large numbers clustering about the rootlets of plants and in fact existing in symbiotic union therewith. This signifies that the relation existing between them is so intimate as to make their vitality mutually dependent. It is therefore quite probable, as has already been intimated, that the preparation of soil particles for plant food is due quite largely to bacterial activity.

KINDS OF ORGANISMS.

The nitric organisms in the soil exist in common with hundreds of others, many of which are doubtless active in the solvent work. The nitrifying organisms themselves, as will be mentioned further on, have such important relations in the supply of nitrogenous food as to have escaped consideration in their more purely solvent action. The attention of bacteriologists has been devoted almost exclusively to a study of the nitrifying organisms in respect of their relation to albu-

minoid and ammoniacal bodies. For this reason the action of these organisms and others relating thereto as a solvent for mineral particles in preparing them for plant absorption has not received the consideration which it merits.

THE NITRIFYING FERMENTS.

The microorganisms of most importance to agriculture, and those to which attention is particularly called in this article, are the bacteria which act upon nitrogenous matters and oxidize them to nitric acid, or which exert a reducing effect on nitric acid, bringing it to lower forms of oxidation, or even to free nitrogen. These organisms belong to many different species, and act in very many different ways. The general group to which these organisms belong is known as nitro-bacteria. The classification of these organisms by genera and species would prove of little interest to the readers of this article. In general it may be said that there are three distinct genera, comprising, in the first place, those organisms which form ammonia or carbonate of ammonia from organic nitrogenous compounds, such as albumen; in the second place, the organisms which transform carbonate of ammonia into nitrous acid; and, in the third place, those which transform nitrous into nitric acid. Each genus is necessary in the complete transformation of proteid matter into nitric acid, in which latter form alone nitrogen is chiefly available for plant food.

FORMATION OF AMMONIA.

The bacteria which are especially active in the formation of ammonia are found constantly in surface soils and in the air and rain waters. By the activity of these organisms in the decomposition of albumen or of an albuminoid body large quantities of ammonium carbonate are produced. The organic carbon, which is present in the compound, is also acted upon during the decomposition of the albumen, and by its oxidation certain organic acids are produced together with carbon dioxide. Any organic sulphur which is present in the original compound becomes converted into an acid. As a rule, nitrogen, in the decomposition of albumen and albuminoid bodies, is not produced in its free state unless, indeed, the denitrifying organisms should attack the products of the first oxidation. The ammonia ferment naturally produces alkalinity in the media in which it is active, but it has been found that its activity is not wholly destroyed even in the presence of a slight excess of acid, provided the amount of acid present does not exceed 1 per cent. As with the case of the other nitrifying organisms, the ammonia ferment is most active in a warm environment. A temperature of from 80° to 100° F. is found most favorable to the production of a maximum fermentative activity. As the temperature approaches the freezing point the activity of the organisms diminishes and finally ceases altogether, but their vitality

is not destroyed. Above a temperature of 110° F. the activity of the ferment is also much diminished and at higher temperatures ceases. A temperature near the boiling point of water continued for some time destroys the vitality of the organisms altogether.

The demonstration of the fact that the transformation of organic nitrogenous matter into ammonia is due to microorganic activity is easily made in the following simple manner: Two samples of the same soil are placed in suitable vessels. The percentages of ammonia and of oxidized nitrogen which these samples contain are determined by the usual chemical process. One of the samples is then sterilized by heating it for a few hours to a temperature considerably above the boiling point of water. After the lapse of a few weeks or months, the ammonia, or its oxidized products, nitrous and nitric acids, is again determined in the two samples. In the unsterilized sample it will be found, provided the soils be kept moist and at the proper temperature, that there is a marked increase of ammonia. In the sterilized sample no such increase will be found.

In general it may be said that the organic matter in the soil which is the source of the ammonia is not altogether albuminoid or proteid matter, but includes also the nitrogenous constituents of humus. Soil humus is remarkably rich in carbon, and under the conditions favorable to nitrification this is constantly suffering oxidation. As a result of this constant oxidation, the percentage of carbon in humus maintained for a long while under cultivation is much less in proportion to the other constituents of that body than in soils which are regularly fertilized with organic matters or in virgin soils.

The exact manner in which microorganisms reduce the nitrogenous stores of humus to the form of ammonia are, of course, not known, and the ferments which are active therein have been the subject of less investigation and are more imperfectly understood than those which are active in the formation of nitrous and nitric acids.

It may be possible that the organism which converts organic matter into carbonate of ammonia and that one which forms nitrous acid are quite similar in their character, but this can not be definitely stated.

PRODUCTION OF NITROUS ACID.

The next step in the process of nitrification is the conversion of ammonia or its compounds into nitrous acid. With a moderate store of ammonia the oxidation into nitrous acid takes place as a rule without any of the nitrogen being lost in a free state or being volatilized as ammonia compounds. When, however, there is a large excess of ammonium carbonate, a considerable loss of nitrogen may take place. The practical deduction to be drawn from this fact is apparent. Nitrogenous fertilizers should be applied only in moderate quantities, so as not to increase the stock of material beyond the power of the active ferments to handle it.

The nitrous ferment is by far the largest and most vigorous of the nitrifying organisms. It is from three to four times as large as the nitric ferment, and under a high power of the microscope appears as minute globules, slightly oblate. These globules are multiplied by spores, which develop rapidly to perfect organisms of full size. In most cases the organisms appear as distinct globules, but many are congregated into masses where the distinctive cell structure seems to be lost.

CONVERSION OF NITROUS INTO NITRIC ACID.

The last step in the process of nitrification consists in the oxidation of nitrous to nitric acid. As a rule plants absorb nitrogenous food only as nitric acid, but it can not be said that the nitrogen may not be used by the plant in other forms. Some experiments seem to show that ammonia and its compounds may be directly absorbed by plants, but if this be true it must be only in a very limited quantity. The final step, therefore, in nitrification is necessary to secure this valuable food in its most highly available state. The nitrifying organisms are much smaller than their nitrous cousins, and of the same general shape but more globular.

It must not be supposed that these steps in the preparation of a nitrogenous food are performed with entire distinctness. The impression might be obtained that the ammoniacal ferment exerted its activity, converting the whole of the nitrogenous supply into ammonia, and that in this state only the nitrous ferment would become active and convert the whole product into nitrous acid which finally, under the influence of the nitric ferment, would form nitric acid. In point of fact, however, in arable soils and under favorable conditions the steps of nitrification may be almost synchronous. In the case of a growing crop, a chemical examination or repeated chemical examinations might find only traces of ammonia and nitrous and nitric acids. As each particle of ammonia is formed it is converted without delay into nitrous acid, and then at once into nitric acid. The nitric acid formed would be absorbed by the growing plant, and thus it might seem that the activity of the ferments present in the soil had been reduced to a minimum, when in point of fact they were exercising their functions with maximum vigor. The separate stages of nitrification mentioned above can only be secured in the laboratory by a skilled bacteriologist patiently working to separate the different genera of nitrifying organisms until he procures them in an absolutely pure form. As may be supposed, this is very difficult to accomplish.

CONDITIONS FAVORING NITRIFICATION.

The further discussion of the character of the microorganisms producing nitrification and their relations with each other, although highly interesting from a scientific point of view, would have no great interest for the practical farmer. For him the most important thing

is to know how to secure in the field the most favorable conditions for the development of those soil ferments upon whose activity the abundance of his crops so intimately depends.

INFLUENCE OF POSITION.

The vitality of a nitrifying organism is as a rule greatly diminished as it occurs at a greater depth below the surface. For this reason it is found that these ferments occur in the greatest numbers and with a maximum vitality near the surface of the soil. It follows from this that the conditions favoring the development of these ferments are largely found in good drainage and good cultivation. In experiments conducted in this division it has been found that in low, wet lands, especially those standing under water for a good portion of the year, the nitrifying organisms are almost unknown. Such a soil may be rich in stores of nitrogenous material, but even after the water has been withdrawn and crops are planted it will be found that they do not grow luxuriantly by reason of the deficiency of the number and vitality of the nitrifying ferments. Practical farmers know very well that in reclaimed lands, after the water has been removed, it is found necessary to thoroughly plow the soil and leave it exposed for one or more seasons before good crops can be produced. One of the chief reasons for this delay is doubtless due to the fact that it requires a considerable time for the nitrifying organisms to be developed and properly distributed through the soil.

EFFECT OF TEMPERATURE.

Another condition favorable to the activity of soil ferments is warmth. As has already been indicated, a maximum activity of these organisms is shown at a temperature of from 85° to 95° F. Everyone who has lived upon a farm knows how rapidly the growth of a crop will be checked by a fall of temperature. It is evident, however, that this depression of temperature does not diminish in the least the quantity of prepared food to which the plant has access. The unfavorable influences of a low temperature are doubtless found not alone in the sluggishness of the movement of the sap through the cellular tissue of the plant, but also in the fact equally as patent that the diminished activity of the soil ferments prevents the rootlets of the plants from absorbing their normal rations of food.

ACTION OF LIGHT.

At this point attention might be called to a fact showing the difference between the activity of the soil ferments and of the plant cells. It is well known that in the latter case, viz, the activity of the plant cells, the influence of light is of the utmost importance. It is true that while plants may grow to a certain extent when deprived of direct sunlight, yet such plants grown in semidarkness never reach matu-

rity, and the products of their vitality are often quite different from those of the normal plant. In etiolated plants—that is, those grown in the dark—are often found products which do not occur at all in those subjected to normal growth. The action of sunlight is therefore indispensable to the full functional activity of the supraterranean parts of plants. On the other hand, it is seen that the action of *sunlight is highly prejudicial to the development of the soil ferments*. Exposed to a bright light, the activity of these ferments is diminished until it reaches practically the vanishing point. Happily, the surface of the soil, being almost impenetrable to light, preserves the organisms lying even near the surface from the deleterious action of the sun. Warm nights, therefore, are even more favorable to the development of soil organisms than warm days, and all are familiar with the phenomenal growth which many plants make during the night.

BENEFIT OF AERATION.

From what has been said above it can be inferred that a proper aeration is also necessary to the development of the functional activity of the fermentative germs. Good drainage and cultivation secure a free circulation of air through the soil and this is essential to the process of nitrification, which is simply oxidation produced by low vegetable organisms. While it is important, as indicated above, to remove the excess of water to secure proper aeration, it should not be forgotten that a certain amount of moisture is necessary for the life of the microorganisms. Experience has shown that when the soil contains from one-third to one-half of the total moisture it is capable of holding, the proper quantity of water is supplied for the most rapid growth of the nitrifying ferments.

UTILITY OF TILLAGE.

Among the influences which favor the process of nitrification tillage of the soil must be mentioned. A thorough breaking up of the soil and of the upper layers of the subsoil is necessary to the aeration which is an indispensable condition to the progress of nitrification. The cultivation of the soil, therefore, in this way not only makes it possible for the rootlets of the plants to extend to a greater distance and thus secure larger quantities of food, but actually increases the available quantity of nitrogenous food in the soil. In connection with thorough drainage the best tillage of the soil thus tends to make available its stores of inert nitrogen.

NECESSITY FOR LIME.

Since the final action of the nitrifying organisms results in the production of nitric acid, it is highly important that the soil contain some substance capable of combining with this acid and thereby preventing its accumulation in a free state. The activity of these ferments is diminished by the presence of an acid and increased by a

moderately alkaline environment. If the acid be allowed to accumulate to a certain point, not only is the activity of the ferments suspended, but a positive injury may be done to a growing crop. All practical farmers know how poorly sour lands respond to cultivation, and this injurious influence is due not only to the action of the acid upon plant growth but also in a high degree to its effect in preventing the evolution of the nitrifying organisms. It is well known that a soil which has an abundant content of carbonate of lime is, as a rule, fertile. The value of lime as a fertilizing agent in many soils is well attested, yet it is certain that this favorable effect is not due to the fact that an additional amount of lime is necessary for plant food. Soils are rarely found which do not contain an abundant supply of lime for all the nutritive needs of plants. It is certain, therefore, that the chief value of the use of lime in agriculture is to be found in some indirect influence which it exerts upon the soil. Heretofore three special methods have been pointed out in which lime exerts a beneficial influence. In the first place, it profoundly affects the physical structure of stiff soils, producing a flocculation of the silt and thus preventing its deposition in individual particles. A well-limed soil is thus apt to be open and porous and easily tilled. In the second place, the lime exerts a certain soluble influence on undecomposed particles of rock, thus favoring their speedy decomposition and the consequent freeing of the potash and phosphoric acid which they contain. In the third place, the added lime tends to correct any acidity of the soil which may be due to the accumulation and excess of humus, or which may arise from imperfect drainage.

It must be admitted, however, that one of the chief benefits of the introduction of lime into a soil is derived from the fact that it favors in a high degree the evolution and development of the nitrifying ferments.

The lime which is used for fertilization is, as a rule, chiefly in the form of oxide or hydrate, that is, slacked lime. After its incorporation in the soil, however, both the oxide and hydrate of lime are rapidly changed to carbonate under the influence of the carbon dioxide (carbonic acid) which is found in the atmosphere of the soil in notable proportions; in fact, in a much higher percentage than in the air. The soil thus becomes permeated with lime carbonate in a fine state of subdivision, a condition especially well suited to favor the growth of the nitroorganisms. Hereafter, therefore, in discussing the benefits of the application of lime, this function of it must receive due consideration. It will not be at all surprising if future investigations should establish the fact that this use of lime is of far more importance in agriculture than any of the others above noted.

SEEDING THE SOIL WITH NITRIFYING ORGANISMS.

In the above paragraphs the conditions favoring the development and activity of nitrifying organisms have been briefly set forth, but

the presence of all these favoring conditions will prove of no advantage in a soil which is practically sterilized. In such a case, however, if a few organisms can be supplied a practically sterilized soil will, after a time, by the natural growth and distribution of nitrifying organisms, become fully impregnated with the nitrifying germs. The question naturally arises, Is there any artificial way in which the seeding of the soil may be accelerated? The answer to this question is undoubtedly affirmative. In experiments which have been conducted in this Department, and of which notice will be made further on, it has been fully demonstrated that different soils differ in the most marked degree in the number and vitality of the nitrifying organisms which they contain. As a rule, the richer the soil or the more highly fertilized it has been and the more fully cultivated, the greater will be the number of the organisms which it contains and the higher the degree of their vitality. It is thus seen that in a field which contains all the elements of fertility, but which by reason of unfavorable conditions, as, for instance, having previously been a swamp or marsh deficient in nitrifying organisms, may be practically sterilized, great benefit may be derived by spreading over it as evenly as possible a little soil taken from a rich garden which has been kept in excellent cultivation. The amount of plant food added in such a soil would not be of any great importance, but the nitrifying organisms thus distributed would rapidly grow in the favorable environment in which they were found and the inert nitrogen of the field be thus speedily prepared for the wants of the growing crop.

The action of stable manure is another instance of the great benefit which is derived from manuring a field with nitrifying organisms. It is well known that the nitrifying ferments of decomposing stable manure are particularly numerous and vigorous. The production of ammonia in a pile of stall manure is often so rapid as to be distinctly noticed by the passer-by from the odor produced. It has long been a matter of wonder among agronomists to find stall manure, when scattered over a field, producing fertilizing results far in excess of what could be expected from the quantity of plant food contained therein. In the light of the facts set forth above, however, these results are no longer surprising. In the distribution of the manure large numbers of a particularly vigorous species of nitrifying organisms are incorporated with the soil, and these and their progeny continue to exercise their activity upon the inert nitrogen of the soil when the more easily nitrifiable portions of the stall manure are exhausted. This result brings to the attention of the scientific agronomist an entirely new factor in the process of fertilization. Even in poor soils chemical analysis often discovers quantities of plant food which seem amply sufficient to produce remunerative crops. The true theory of fertilization, therefore, not only looks to the addition of appropriate plant foods to a soil deficient therein, but also to the making available the stores of plant food already present.

FERTILIZING FERMENTS.

When a soil is practically free from albuminoid bodies and contains but little humus, the attempt to develop a more vigorous nitrifying ferment would be of little utility. Even in a soil containing a considerable degree of humus, it may be found that its nitrogen content has been so far reduced as to leave nothing practically available for the activity of nitrification. In such cases the only rational method of procedure is in the application of fertilizers containing nitrogen. In other cases where the lack of fertility is due to the extinction or attenuation of the nitrifying ferment, remunerative results may be obtained by some process of seeding similar to that described above. It is entirely within the range of possibility that there may be developed in the laboratory species of nitrifying organisms which are particularly adapted for action on different nitrogenous bodies. For instance, the organism which is found most effective in the oxidation of albuminoid matter may not be well suited to convert amides or the inert nitrogen of humus into nitric acid. We have already seen the day when the butter maker sends to a laboratory for a ferment best suited to the ripening of his cream. It may not be long until the farmer may apply to the laboratory for particular nitrifying ferments to be applied to such special purposes as are mentioned above. Because of the extreme minuteness of these organisms the too practical agronomist may laugh at the idea of producing fertility thereby, and this idea, indeed, would be of no value were it not for the wonderful facility of propagation which an organism of this kind has when exposed in a favorable environment. It is true that the pure cultures which the laboratory would afford would be of little avail if limited to their own activity, and it is alone in the possibility of their almost illimitable development that their fertilizing effects may be secured.

NUMBERS AND KINDS OF NITRIFYING ORGANISMS.

In regard to the numbers and kinds of organisms which take part in the oxidation of nitrogenous bodies, our knowledge is limited. It has already been noted that a great many species take part in the production of ammonia. The purely nitrous and nitric ferments seem to be of a more limited character, but it must not be forgotten that scarcely a beginning has been made in the investigation of these bodies, and it is entirely probable that great differences in their nature will be established. It is not at all likely, for instance, that a nitrifying organism such as exerts its activity in an ordinary soil under ordinary conditions would belong to a species which was capable of development and work in an entirely different medium. There are in the arid regions indubitable evidences of strong nitrifications in the presence of highly alkaline salts. While it is true that a slight alkalinity favors the ordinary form of nitrifying activity, it is likewise

certain that such organisms would be practically paralyzed if subjected to the alkaline environment of the arid plains. It is therefore highly desirable that the investigation of these organisms be pushed to the widest extent, not only for the scientific value of the investigation, but also for its practical utility in scientific farming. This is one of the objects kept in view in the investigations which the Department has undertaken in respect of the extent and character of the nitrifying ferments in the typical soils of the United States.

FERMENTS OXIDIZING FREE NITROGEN.

In the preceding paragraphs the attention of the reader has been briefly called to the action of those species of ferments which attack nitrogen in some of its forms of combination. Since nitrogenous food is the most expensive form of nutriment which the plant consumes, it is a matter of grave importance to agriculture to know the full extent of the supply of this costly substance. It is evident that the continued action of nitrifying ferments finally tends to exhaust the stores of this substance which have been provided in the soil. The quantities of oxidized nitrogen produced by electric discharges in the air and by other meteorological phenomena, and which are brought to the soil in rain waters, are of considerable magnitude, but lack much of supplying the ordinary wastage to which the stores of soil nitrogen are subjected. Even with the happiest combination of circumstances it is not difficult to see in what way the available stores of nitrogen could be diminished to a point threatening the proper sustenance of plants, and thus diminishing the necessary supplies of human food. The examination of the drainage waters which come from a fertile field in full cultivation is sufficient to convince the most skeptical of the fact that the growing crop does not by any means absorb all of the products of the activity of the nitrifying ferments. Nitric acid and its compounds, the nitrates, are exceedingly soluble in water, and for this reason any unappropriated stores of them in the soil are easily removed by heavy downpours of rain. Happily the living vegetable organism has the property of withholding nitric acid from solution, either by some property of its tissues or more probably by some preliminary combination which the nitric acid undergoes in the plant itself. This is easily shown by a simple experiment. If fresh and still living plants be subjected to the solvent action of water, very little nitric acid will be found to pass into solution. If, however, the plants are killed before the experiment is made, by being exposed for some time in an atmosphere of chloroform, the nitric acid which they contain is easily extracted by water.

The losses, therefore, which an arable soil sustains in respect of its content of nitrogenous matter must be supplied either by the addition of nitrogenous fertilizers or by some action of the soil whereby the nitrogen which pervades it may be oxidized and fixed in a form suited

to the nourishment of plants. The discussion in regard to the possibility of fixing nitrogen in the soil has been carried on with great vigor during the last two decades. The proof, however, is now overwhelming that such fixation does take place. It would not be proper here to enter into a discussion of the processes by which this fixation is determined, and, in fact, they are not definitely known. One thing, however, is certain, viz, that it is accomplished by means of micro-organisms or ferments similar, perhaps, in their nature to those already mentioned, but capable of absorbing, assimilating, and oxidizing free nitrogen.

METHODS OF OXIDIZING FREE NITROGEN.

At the present time it is sufficiently well known that this operation takes place in two ways. In the first place, there are found to exist on the rootlets of certain plants, chiefly of the leguminous family, colonies of bacteria whose function is known by the effects which they produce. In such plants in a state of maturity, as was mentioned above, are found larger quantities of organic nitrogen than could possibly have been derived from the soil in which they were grown or from the fertilizers with which they were supplied. Cultural experiments in sterilized soils, with careful exclusion of all sources of organic nitrogen, have proved beyond question that this gain in nitrogen is found only in such plants as are infected by the organism mentioned. The logical conclusion is therefore inevitable that these organisms, in their symbiotic development with the plant rootlets, assimilate and oxidize the free nitrogen of the air and present it to the plant in a form suited to absorption. Attempts have been made to inoculate the rootlets of other families of plants with these organisms, but so far without any pronounced success. There are, however, certain orders of low vegetable life, such as cryptogams, for instance, which seem to share to a certain degree the faculty of the leguminous plants in acting as a host for the nitrifying organisms mentioned. The observation above recorded becomes a sufficient explanation of the fact that the fertility of fields is increased by the cultivation of leguminous plants, which would not be possible except they could develop some such property as that which has already been described.

Another order of organisms has also been discovered which is capable of oxidizing free nitrogen when cultivated in an environment from which organic nitrogen is rigidly excluded. It seems probable, therefore, even in soils which bear crops not capable of developing nitrifying organisms on their rootlets it is possible that the actual stores of available nitrogen may be increased. This fact explains the observation which has frequently been made that in fields which are not cultivated but which remain in grass there may be found an actual increase in the total amount of nitrogen which is available for plant growth. As will be seen further along, the soil is also infested with

an organism which is capable of destroying nitric acid and returning the nitrogen which it contains to the air in a free state. It seems almost certain that in every complete decomposition of a nitrogenous organism a part of the nitrogen which it contains escapes in the free state. Were it not, therefore, for the fact that this free nitrogen can be again oxidized and made available for plant growth the total stores of organic nitrogen in existence would be gradually diminished, and the time would ultimately come when their total amount would not be sufficient to sustain a plant life abundant enough to supply the food of the animal kingdom. Thus the earth itself, even without becoming too cold for the existence of the life which is now found upon it, might reach a state when plant and animal life would become practically impossible by reason of the deficit of nitrogenous foods.

Much less is known concerning the character and activity of the organisms that oxidize free nitrogen than of those which feed upon organic nitrogen. It can not be doubted, however, that these scarcely known ferments are of the greatest importance to agriculture, and the further study of their nature and the proper methods of increasing their activity can not fail to result in the greatest advantage to the practical farmer.

FERMENTS INIMICAL TO AGRICULTURE.

It has been noticed by many observers that when nitric acid is subjected to certain fermentative processes it becomes decomposed and gradually disappears. In studying the causes which lead to this decomposition it is found that it is due to the action of a micro-organism or ferment, which, by reason of the result of its functional activity, is called a denitrifying organism. While it is true that in numbers and activity this denitrifying organism does not equal its nitrifying relation, yet it is a matter of no inconsiderable importance to know fully the laws which govern its existence. As in the case of the bacteria which are found in ripening cream, where some produce evil and some good effects, so it is also with those in the soil. The favoring organisms, whose functional activity prepares nitrogen in a form suited for plant food, are accompanied by others, doubtless nearly related to them, whose functional activity tends to destroy the work which the first have accomplished. It thus happens that in the fermentation of nitrogenous bodies there is danger of losing, as has already been said, a part of the nitrogen, which may either escape as gaseous oxides unsuited for the sustenance of plants, or even as free nitrogen. The object, at least the practical object, of the investigation of these denitrifying organisms should be to discover some process by which their multiplication could be prevented and their activity diminished. At the present time all that is known is that in favoring circumstances these organisms are not developed in sufficient numbers to prove very destructive. It has already been mentioned,

however, that in case of a very great excess of organic nitrogenous matter a considerable quantity of the nitrogen therein contained may, through the action of these organisms, be lost. The practical lesson taught here is to apply nitrogenous foods in a moderate manner and avoid every unnecessary excess.

PATHOGENIC FERMENTS.

There are also other forms of ferments in the soil of an objectionable nature which are not related to the nitrifying organism. It has been observed in France that in localities where animals are interred which have died of charbon the germs of this infectious malady persist in the soil for many years, and that, especially when cereal crops are cultivated upon such soils, there is great danger of contaminating healthy cattle with the same disease. In one case it was observed that many sheep which were pastured in a field in which, two years before, a single animal which had died of charbon was buried were infected with the disease and died. In like manner, it is entirely probable that the germs of hog cholera may be preserved in the soil for many years to finally again be brought into an activity which may prove most disastrous for the owners of swine. Every effort should be made by agronomists to avoid infecting the soil by the carcasses which are dead from any zymotic disease. Cremation is the only safe method of disposing of such infected carcasses. The investigations of scientists have shown that there are many diseases of an infectious nature due to these germs, and that these germs may preserve their vitality in the soil. Among others may be mentioned yellow fever and tetanus.

USE OF SEWAGE AS FERTILIZER.

For the reasons given above, the agronomist who also has at heart the health and welfare of man and beast can hardly look with favor upon any of the plans which have been proposed for the use of sewage from large cities for irrigation purposes. There is scarcely a time in any large city when some infectious disease, due to the activity of germs, does not exist, and the sewage is liable at all times to be contaminated therewith. In view of the fact that the vitality of the germs mentioned above may be continued for a long time in the soil, it is fair to conclude that it is of the utmost importance to avoid the contamination of the soil, where it is to be used for agricultural purposes, with any of the dejecta which may come from those infected with any zymotic disease whatever.

THE STORAGE OF NITRATES.

Attention has already been called to the fact that the activity of the nitrifying ferments in a soil is, as a rule, greater than the needs of the growing crop. For this reason the waters of drainage are found to be more or less impregnated with nitrates. The sea is

eventually the great sorting ground into which all this waste material is poured. The roller processes of nature, like the mills of the gods, grind exceedingly slow and small, and the sea becomes the bolting cloth by which the products of milling are separated and sorted out. Not only do the drainage waters carry nitrates, but also potash, phosphoric acid, lime, and other soluble materials of the soil. As soon as this waste material is poured into the sea, the process of sifting at once begins. The carbonate of lime becomes deposited in vast layers, or by organic life is transformed into immense coral formations or into shells. Phosphoric acid is likewise sifted out into phosphatic deposits or passes into the organic life of the sea. Even the potash, soluble as it is, becomes collected into mineral aggregates or passes into marine animal or vegetable growth.

All these valuable materials are thus conserved and put into a shape in which they may be returned sooner or later to the use of man. In the great cosmic economy there is no such thing as escape of any valuable material from usefulness. The nitrates which are poured into the sea are sooner or later absorbed by the seaweed or other marine vegetation, or serve for the nourishment of the animal life of the ocean. It is highly probable that the great deposits of nitrates found in certain arid regions, notably in Chile, are due to the decomposition of marine vegetation. There must be present in the sea vast fields of vegetation which, growing in water largely impregnated with nitrates, become highly charged with organic nitrogenous matter. In the changes of level to which the surface of the earth is constantly subjected, the depths of the sea often become isolated lakes. In the evaporation of the water of these lakes, such as would take place in arid regions, immense deposits of marine vegetation and common salt would occur. In the oxidation and nitrification of this organic matter, due to fermentative action, the organic nitrogen would be changed into the inorganic state. In the presence of calcareous rocks the nitrate of calcium would be formed, which finally, by double decompositions, would result in the formation of nitrate of soda, the form in which these deposits now exist. The fact that iodine is found in greater or less quantity in these deposits of soda saltpeter is a strong argument in favor of the hypothesis that they are due to marine origin. Iodine is found only in sea and never in terrestrial plants. Further than this, attention should be called to the fact that these deposits of nitrate of soda contain neither shells nor fossils, nor do they contain any phosphate of lime. It is hardly credible, therefore, that they are due to animal origin. The activity of ferments in these great deposits of marine plants, although taking place perhaps millions of years ago, has served to secure for the farmers of the present day vast deposits of nitrate of soda which prove of the utmost value in increasing the yield of the field. To every quarter of the globe where scientific agriculture is now practiced these deposits are

sent. They are of such vast extent that it is not likely they will soon be exhausted, and the labors of the agriculturist for many hundreds of years to come will continue to be blessed by reason of the activity of the insignificant microscopic ferments which plied their vocation in past geological epochs.

Because at the present time there are no known deposits of marine vegetation undergoing nitrification, is no just reason for doubting the accuracy of the above-mentioned hypothesis. Our geologists are not acquainted at present with any locality in which deposits of phosphate are taking place, but the absence of the process can not be used as a just argument against any of the theories which have been proposed to account for the immense deposits of this material which are found in various parts of this and other countries. Another illustration of this point may be found in the coal deposits. The environment which determines the geologic conditions now is not favorable to the development of large quantities of organic matter from which coal might be produced by changes in the level of the earth's surface. In fact, all the teachings of paleontology show beyond a doubt that life in the past geological ages was on a far larger scale than at present. In those remote times the mean temperature of the earth's surface was very much greater than it is at the present time. There are many indubitable evidences of the fact that high equatorial temperatures prevailed even at the poles, while the present tropic and temperate zones were probably too warm for any forms of life which now exist. The fossil remains of animals and plants of those ages show the gigantic scale on which all animal and vegetable life was formed. When crocodiles were nearly 70 feet in length and dragon flies 3 feet long it is not surprising that both terrestrial and marine vegetation existed in a far more exuberant form than at present. The dense terrestrial vegetation which made the coal deposits possible were doubtless equaled by marine vegetable growth capable, by oxidation under favorable circumstances, of forming the vast deposits of nitrates which have been discovered in various parts of the world. The depression of the surface of the land which enabled the coal measures to be developed beneath the surface of the sea, was doubtless compensated for by the elevation of the marine forests into a position favoring the deposits of nitrates. The wonderful conservative instincts of nature are thus demonstrated in a most remarkable manner in restoring to the fields the nitrates leached therefrom in past ages.

GENESIS OF GUANO.

The fermentative action of germs in the production of nitrates on a small scale and their storage to a limited extent are found going on in many caves at the present time. In these localities large numbers of bats formerly congregated, and the nitrogenous constituents of

their dejecta and remains, collecting on the floors of caves practically devoid of water, have undergone nitrification and become converted into nitric acid. In a similar manner the deposits produced in rookeries, especially in former ages, have been converted into nitric acid and preserved for the use of the farmer. The well-known habits of birds in congregating in rookeries during the nights and at certain seasons of the year tend to bring into a common receptacle the nitrogenous matters which they have gathered and which are deposited in their excrement and in the decay of their bodies. The feathers of birds are particularly rich in nitrogen, and the nitrogenous content of their flesh is also high. The decay of the remains of birds, especially if it take place in a locality practically excluded from the leaching action of water, serves to accumulate vast deposits of nitrogenous matter, which is at once attacked by the nitrifying ferments. If the conditions in such deposits are particularly favorable to the process of nitrification, the whole of the nitrogen, or at least the larger part of it which has been collected in these débris, becomes finally converted into nitric acid, and is found combined with appropriate bases as deposits of nitrates. The nitrates of the guano deposits and of the deposits in caves, as has already been indicated, arise in this way. If these deposits be subject to moderate leaching, the nitrates may become infiltered into the surrounding soil. The bottoms and surrounding soils of caves are often found highly impregnated with nitrates.

IMPREGNATION OF SOILS WITH NITRATES.

When, on the other hand, these deposits take place in regions subjected to heavy rains, the nitric acid which is formed is rapidly removed, to be returned to the ocean and begin anew the circuit of life which will finally restore it to the land. By reason of the accumulation of nitrogenous matters in tropical regions, especially where there is deficient rainfall, it has been found that the soils of those regions contain a very much larger percentage of nitrates than is found, for instance, in the soils of the United States. These nitrated soils are very abundant, especially in Central and South America, where they cover large surfaces. In these soils the nitric acid, as a rule, is found in combination with lime, while in the purer deposits of nitric acid it is almost constantly found in combination with soda. In some South American soils as much as 30 per cent of nitrate of lime has been found. Not only birds serve thus to secure deposits of nitrogen, but large quantities of guano rich in nitrates have their origin in the débris of insects, fragments of elytra, scales of the wings of butterflies, and other animal matters which are often brought together in quantities of millions of cubic meters. The products of nitrification in these deposits may also be absorbed by the surrounding soils. Some localities produce such great quantities of nitrate of lime (which is a salt easily absorbing water) as to convert the soil in

their immediate neighborhood into a plastic paste. In all the deposits such as are described above are found large quantities of phosphoric acid and sufficient remains of animal life to show in a positive manner their origin. It is thus seen that there is a very marked difference between the character of the deposits of nitric acid due to terrestrial animal origin and those which have been derived from a marine vegetable source. An economic observation of some importance may be made here, viz, to the effect that when in the future the deposits of nitrate of soda due to marine origin are exhausted it may still be possible to keep up the supply demanded for agricultural use by leaching the highly impregnated soils above mentioned and thus securing the nitric acid in a form sufficiently concentrated to make its transportation profitable.

PROPERTIES OF NITRATE OF SODA.

Practically the only form of oxidized nitrogen which is of commercial importance, from an agronomic point of view, is sodium nitrate, *commonly known in commerce as Chile saltpeter.* The nitrate of potash, a nearly related salt, is also of high manurial value, but on account of its cost and the importance of its use in the manufacture of gunpowder, it has not been very extensively applied as a fertilizing material. When Chile saltpeter is applied to a growing crop it becomes rapidly dissolved, especially at the first fall of rain or by the moisture normally existing in the soil. It carries thus to the rootlets of plants a supply of nitrogen in the most highly available state. There is, perhaps, no other kind of plant food which is offered to the living vegetable in a more completely predigested state and none to which the growing plant will yield a quicker response. By the very reason of its high availability, however, it must be used with the greatest care. A too free use of such a stimulating food may have in the end an injurious effect upon the crop and is quite certain to lead to a waste of a considerable portion of expensive material. For this reason Chile saltpeter should be applied with extreme care in small quantities at a time and only when it is needed by the growing crop. It would be useless, for instance, to apply this material in the autumn with the expectation of its benefiting the crop to a maximum degree the following spring. If the application of the manure should be made just previous to a heavy rain, it is not difficult to see that nearly the whole of it might be removed beyond the reach of the absorbing organs of the plant.

DECOMPOSITION OF SODIUM NITRATE.

The molecule of sodium nitrate is decomposed in the process of absorption of the nitric acid. The plant presents a selective action to its constituents, the nitric acid entering the plant organism and the soda being rejected. Soda, however, may not be without its uses, for,

doubtless being at some time in a practically nascent or hydrated state, it may play a rôle of some considerable importance in decomposing particles of minerals containing phosphoric acid. It is probable that the decomposition of the sodium nitrate takes place in the cells of the absorbing plant, for it is difficult to understand how it could be accomplished externally except by a denitrifying ferment. While the soda itself is therefore of little importance as a direct plant food, it can hardly be dismissed as of no value whatever in the process of fertilization.

Many of the salts of soda, as, for instance, common salt, are quite hygroscopic, and serve to attract moisture from the air and thus become carriers of water between the plant and the air in seasons of drought.

The Chile saltpeter of commerce may reach the farmer in the lumpy state in which it is shipped, or finely ground ready for application to the fields. Unless the farmer is provided with convenient means for grinding, the latter condition is much to be preferred. It permits of a more even distribution of the salt, and thus encourages economy in its use.

NEED OF SODIUM NITRATE.

The question of when the soil needs an application of Chile saltpeter is often one of great importance, and the farmer would do well, before applying a great deal of this expensive fertilizer, to consult the agricultural experiment station of his locality, or should determine the actual needs of his soil by experiments upon small plats. The quantity of Chile saltpeter which should be applied per acre varies with so many different conditions as to make any definite statement concerning it unreliable. On account of the great solubility of this salt no more should be used than is necessary for the temporary nutrition of the crop. For each 100 pounds of it used, from 14 to 15 pounds of oxidized nitrogen would be added to the soil. Field crops, as a rule, require less of the salt than garden crops. In field crops there is an economic limit to the application of the salt which should not be passed. As a rule, 250 pounds per acre should be a maximum dressing. The character of the crop must also be taken into consideration. Different amounts are required for sugar beets, tobacco, wheat, and other standard crops. Cereal crops, especially, absorb a high percentage of the nitrogen in Chile saltpeter judiciously applied. As a rule, Chile saltpeter should be used as a temporary supply. Its presence diminishes to a certain extent the necessity for the activity of the nitrifying ferments, and its long-continued use in sufficient quantities would evidently cause an enfeeblement of those organisms.

CONSUMPTION OF SODIUM NITRATE.

The entire consumption of Chile saltpeter for manurial purposes throughout the world at the present time is perhaps a little over a

million tons annually, of a total value, delivered to the farmer, of over $40,000,000. The approximate amounts annually consumed in different countries are as follows:

	Tons.
Germany	400,000
France	200,000
Belgium	125,000
England	120,000
United States	100,000
Holland	60,000
Italy and Spain	5,000
Other countries	6,000

VALUE OF CHILE SALTPETER.

Chile saltpeter has a moderate value at the factories in Chile where it is prepared for shipment. Its high cost at the ports where it is delivered for consumption is due chiefly to the freights and the profits of the syndicate controlling the business.

The factories where it is prepared for the market are at or near the deposits, and the freights thence to the seacoast in Chile are very high. The railroads which have been constructed to the high plateaux which contain the deposits have been built at a very great cost, and the freights charged are correspondingly high. There is also a tax of $1.20 levied by the Chilean Government on each ton exported. Deducting all costs of transportation and export duties, the actual value of sodium nitrate at the factory ready for shipment is about $16 in gold a ton.

METHODS OF PRESERVING NITRATES IN THE SOIL.

It is not possible at all times to maintain an equilibrium between the activity of the nitrifying organism and the needs of a growing crop. There are times when the amount of nitric acid produced is greater than the crop demands, while at other periods the needs of the crop may be far in excess of the ability of the organisms to supply. In the one case there will be a necessary increase in the amount of nitrates in the soil, while in the other the vigor of the growing crop will be at least temporarily checked. There are many practical points connected with this matter which must be of great interest to the farmer. As a rule, farming operations are carried on for profit and not for pleasure, and for this reason the more practical the results of scientific study the more useful they become to the great mass of agriculturists. The rich man who farms for pleasure can easily afford expenses in the way of fertilizers which the practical farmer must avoid. Happily, at those seasons of the year when crops grow least vigorously the activity of the nitrifying organisms is reduced to a minimum. For instance, the amount of nitric acid which is produced during the winter is a very small quantity as compared with the

production during the warm months. In the natural order of things, therefore, there is a tendency to conserve to the utmost the products of nitrification.

ABSORPTION OF NITRATES BY PLANTS.

Evidently, the very best method of utilizing the products of the activity of the soil ferments is to have them absorbed by a growing crop. For this reason, as well as for others of an economical nature, the farmer should have as little waste land as possible. Every acre which he possesses should either be devoted to forest, orchard, grass, pasturage, or cultivated crops. By thus occupying the land he will reduce to a minimum the losses which occur from the leaching of the soil by water.

It is well known that all agricultural crops store immense quantities of organic nitrogen in their tissues. As a rule, the highest percentages of nitrogenous organic compounds are found in the seeds of plants, but it must not be forgotten that certain grasses which are harvested for hay also contain large quantities of nitrogen. This is especially true of clover. It is easily seen from the above how wasteful is the practice, now happily almost extinct, of burning the residue of cereal crops, as, for instance, Indian cornstalks and the straw of wheat, in order to prevent them from obstructing subsequent tillage. In this wasteful process it is true that the phosphoric acid and potash are saved and returned to the soil, but all the nitrogenous compounds are practically lost and dissipated in the air. The quantity of ammonia and oxids of nitrogen which are produced in combustion is insignificant when compared with the total nitrogenous content of the refuse matters mentioned above. It is far better that these residual matters be chopped as finely as possible and turned under by the plow. Although they may not decay with sufficient rapidity to be of much benefit to the next crop, yet they will gradually become decomposed and serve a most valuable end in contributing fresh stores of humus and nitrogen to the arable soil. Combustion is the most wasteful and also the least scientific method of disposing of the refuse of the fields.

FALLOW FIELDS.

In former times it was a common practice among farmers to allow a field to lie fallow for one season in order to increase its fertility. The advisability of this process is extremely questionable. During a moderately dry summer there is probably very little loss experienced by plowing a field after the spring rains and keeping its surface sufficiently well cultivated during the summer to prevent the growth of weeds. In the absence of heavy rainfall the stores of available nitrogen in such a soil will undoubtedly be increased during the summer, inasmuch as the processes of nitrification will be continued and the stores of nitrogen thus oxidized, in the absence of absorbing bodies,

will remain in the soil. Even in case of rainfalls which may carry the soluble plant food below the arable soil, there may not be any notable loss, especially if such a downpour be followed by dry weather. In the latter case, by the evaporation from the surface and consequent capillary movement of the soil moisture upward, the available plant food carried below the reach of the rootlets of plants will be brought again toward the surface and rendered available. But in case of heavy rains, producing a thorough saturation and leaching of the soil, the losses in a field lying fallow during the summer will be very great, and it is not well at any time to take the risk. Especially is this statement true of fields which have lain fallow during the summer and which are afterwards exposed to the saturating rains of the autumn and winter. In these cases the nitrogen will be thoroughly extracted and all the soluble matters which may have accumulated during the summer will be lost. It is advisable therefore in all cases, instead of allowing the fields to lie fallow, to seed them with a catch crop, such as barley, rye, or peas, which may retain the products of nitrification. When the time comes for seeding the field with the intended crop the catch can be turned under with the plow and, in the process of decay, furnish again the nitrogenous food in an available form. This practice should never be neglected in fields which lie over during the winter in preparation for planting during the following spring. Of course, this statement does not apply so particularly to fields which may be plowed late in the autumn, after the activity of the nitrifying ferments is practically suspended for the winter. In a temperate climate fields may be plowed late in November or during the month of December and the freshly turned soil be exposed to the action of the weather during the winter without great danger of loss.

In many localities even an earlier period might be chosen for the autumn plowing, which should be deep or accompanied by subsoiling. The loosened soil should be brought into good tilth and thus form an absorbent which will hold large quantities of moisture, becoming available for the following season during the period of deficient rains.

THE SUPPLY OF RAW MATERIAL FOR THE ACTION OF FERMENTS.

A field is as poor as its most deficient fertilizing principle. A plant, like an animal, demands a balanced ration. It can not live upon phosphoric acid alone. In order to secure the most economic method of fertilizing, the peculiarities of each field must be carefully studied and its particular deficiency in plant food determined. In the case under consideration it may happen that a field will have an abundant supply of potash and phosphorus and be deficient only in nitrogen. In such a case its pristine fertility will be restored by the application of nitrogen alone, provided the other conditions in the composition of the soil are favorable to the development and activity of the ferments which oxidize nitrogen. Virgin soils as a rule are extremely rich in

nitrogen. This arises from several causes. In the first place, such soils usually contain a large quantity of humus, and this humus is exceptionally rich in its nitrogenous elements. In the second place, a virgin soil is apt to be well protected from leaching. This is secured either by a forest growth or, on prairie land, by the grass. In the third place, there is a well-marked tendency in soils, especially those covered by grass, and presumably those also protected by forest growth, to develop ferments capable of oxidizing the free nitrogen of the air. When virgin soils are subjected to cultivation, it is found that their nitrogen content as a rule diminishes most rapidly as compared with that of the other leading plant foods. Hence it becomes necessary sooner or later, if maximum crops are to be maintained, to supply nitrogenous food. Attention has already been called to the use of the stores of nitrogen which have already been oxidized for fertilization. It is evident, however, that only a very small part of the nitrogenous needs of arable fields can be supplied in this way. Further than this, it must not be forgotten that in the use of a substance like Chile saltpeter there is added to the soil a material which can in no manner foster the growth and development of nitrifying organisms. To feed a soil with a food of this kind alone, therefore, would be to virtually produce a famine in respect of the nitrifying ferments which it contains.

It is therefore highly important that additional methods of supplying the nitrogenous foods of plants should be practiced. Stall manures and the refuse of cattle and poultry yards furnish considerable quantities of nitrogenous materials suited to the needs of the soil ferments, and useful after oxidation to the growing crop. In the growth of leguminous plants, as has already been intimated, another important supply of organic nitrogen may be secured, some of which, at least, is a clear gain from the atmosphere. Other important forms of nitrogenous materials are found in the pressed cakes left after the extraction of the oil from oil-producing seeds, such as flax and cotton seed. These cakes are exceptionally rich in nitrogenous matter, which may be secured for the field both by the direct application of the ground material to the soil or by first feeding it to animals, the part which escapes digestion in the latter case being still a valuable fertilizing material. In the case of cotton-seed cake, moreover, it should not be forgotten that there is some danger in feeding it, especially to young cattle, on account of the poisonous nitrogenous bases (cholin and betain) which it contains. These poisonous bases produce no deleterious effects whatever in the soil, although it is doubtful whether they are attacked very readily by the nitrifying ferments. Other sources of nitrogenous foods for the soil ferments are found in the refuse of slaughterhouses. Dried blood is perhaps the richest in nitrogen of any organic substance that is known, and is readily attacked by the soil ferments. The nitrogenous refuse of slaughtered animals, after

the extraction of the fat, is dried and ground and sold under the name of tankage. It is a substance very rich in nitrogenous matter. The bones of animals are not only valuable on account of the phosphoric acid which they contain, but also have a large percentage of nitrogenous material which renders them particularly well suited for application to a soil deficient both in phosphoric acid and nitrogen. For this reason, burning bones before grinding them for fertilizing purposes, which is done in some localities, is extremely wasteful. For a similar reason, also, the composting of coarsely ground fresh bones with wood ashes is not to be recommended because of the tendency of the alkali of the ashes to set free, in the form of ammonia, at least a part of the nitrogenous content of the bones.

CONTRIBUTIONS FROM THE OCEAN.

The farmer, happily, is not confined alone to the land for the sources of organic nitrogen with which to supply the demands of the nitrifying ferments of his field. The ocean is made to contribute to the stores of nitrogenous matters to which the farmer has access. The vast quantities of seaweed which are thrown up annually upon our shores are rich in nitrogenous matters. The value of this material, however, is not generally appreciated, but in some parts of the country it is carefully gathered and utilized. The value of this product gathered annually upon the shores of Rhode Island alone is nearly $100,000. While seaweed, for obvious reasons, can only be successfully applied in marine littoral agriculture, yet the extent of agricultural lands bordering on the sea is so great as to render the commercial importance of the matter of the highest degree of interest. Seaweed is not valuable for its nitrogenous constituents alone, but also carries large quantities of potash and phosphoric acid, and thus, to a certain degree, it may be regarded as a complete fertilizer. But the seaweed which is thrown upon our shores is not the only source of nitrogenous food which we receive from the ocean. In the animal life of the ocean are gathered vast quantities of nitrogenous materials. The quantity of albuminoid matter in the water-free substance of the flesh of fish is enormously high as compared with that of ordinary foods. It may be said to be, approximately, 75 per cent of the water-free substance. Some varieties of fish are taken alone for their oil product and agricultural value. This is especially true of the menhaden, vast quantities of which are annually brought to land, and after being passed through the oil factory are ground and distributed as fish scrap to the manufacturers of fertilizers. The practice of using fish for fertilizing purposes is many centuries old; but until recent years the farmers residing along the coast were the only ones receiving any benefit therefrom. At the present time the nitrogenous elements taken from the sea find their way to the gardens, truck lands, and fields of the interior.

RELATION OF DIFFERENT CROPS TO FERMENTATIVE ACTIVITY.

It is a well-established principle of farming that there are certain crops which can not be grown continuously upon the same field, while in the case of other crops almost an indefinite growth can be secured. Broadly, it may be said that cereals can be grown upon the same field almost indefinitely and without fertilization. In such cases the large crops of cereals which are at first obtained rapidly diminish in quantity until they reach a certain minimum limit, at which point they tend to remain, with variations in yield due only to seasonal influences. On the other hand, root crops of all kinds, and especially leguminous crops, do not continue to flourish upon the same soil, even when liberally fertilized. The necessity for rotation, therefore, is far greater in the latter class of crops than with the cereals. It appears from the result of the scientific investigations attending this difference of behavior that the relations of these two classes of growing crops are different toward the soil ferments. In the case of the cereals the quantity of nitrogen which they require can be obtained from humus, or other sources, with little effort. In the case of the other class of crops, such as root crops and those of a leguminous nature, it appears that the humus should be particularly rich in nitrogen, and that when by the activity of the soil ferments the percentage of nitrogen is reduced to a certain limit there is no longer a possibility of a sufficiently vigorous nitrification to meet the demands of the growing vegetables. There is thus a scientific basis, as well as practical reasons, for a frequent rotation of crops. Even in the case of cereals, which, as mentioned above, can be grown with considerable success without rotation, experience has shown that a change from one crop to another is always beneficial.

THE RELATION OF HUMUS TO SOIL FERMENTS.

The term humus is applied to those constituents of the soil which have been derived chiefly from the decay of vegetable matter. In this decay the original structure of the vegetable has been entirely lost, and the residue, in the form of vegetable mold of a black or brownish color, is left distributed in the soil. In the processes of decay the organic matter of the vegetable is converted largely into acids of the humic series and the nitrogenous principles of the plant become changed from an albuminoid to a more inert form, in which it is more readily preserved. It is this practically inert form of nitrogen on which the soil ferments exercise their activity in preparing it for the uses of the plant. It has been a commonly accepted theory in the past, especially since the time of Liebig, that the organic principles of humus of every description suffer entire decomposition under the action of fermentative germs before being absorbed as plant nutriment. Recent investigations, however, tend to show that in some instances the organic elements of humus itself may serve as

food for plants without undergoing entire decomposition. Whether or not the nitrogenous principles of the humus can thus be employed has not been determined, but that the humus itself, or some constituents thereof, can be absorbed by the plant I have myself often noticed, especially in the case of sugar cane grown upon a rich vegetable mold. The juices expressed from such canes contain the organic matter of the humus to a certain extent unchanged, and the sugar and molasses made therefrom are distinctly impregnated in the raw state with this organic matter.

These facts have a tendency to raise again the question concerning the purely mineral character of plant food, which for many years was considered as definitely settled. Recent progress in synthetic chemistry has shown that there is no impassable barrier between organic and inorganic classes of compounds. By the union, for instance, of lime and carbon under the influence of the electric arc, a substance is obtained—calcium carbide—which, when thrown upon water, evolves the gas, acetylene, which was formerly supposed to be wholly of organic origin. In hundreds of other instances the barriers between organic and inorganic substances have been broken down in the laboratory, and organic bodies as complicated in their nature as sugars have been formed by pure synthesis. The chemistry of the vegetable organism is admittedly superior to that of the chemical laboratory, and while there is no doubt of the fact that the vast preponderance of vegetable food is of a mineral nature, it would not be safe to deny to the vegetable the ability to absorb to a certain extent organic compounds.

There is, however, at the present time but little evidence to show that organic compounds of a nitrogenous nature are ever absorbed by plants, and therefore, even in the case of humus, we must still contend, at least for the present, that its nitrogenous constituents only become available for plant food after having been fully oxidized by the action of the soil ferments.

DETERMINATION OF THE ACTIVITY OF SOIL FERMENTS.

It is evident from the preceding pages that a study of the soil for agricultural purposes is incomplete which does not include a determination of the character and vigor of the ferments which it contains. This necessarily introduces into the practice of soil analysis the processes of bacteriological examination. It is not the purpose at the present time to describe these processes, but to give only to the general reader as clear an idea as possible of the principles which underlie the analysis of soils for the purpose of determining the activity of their nitrifying ferments.

PRECAUTIONS IN SAMPLING.

First of all, the method of sampling must be such as to secure for examination portions of soil which certainly contain no other

organisms than those locally found therein. The methods of securing the samples are purely technical and will be fully described in a special bulletin from the Division of Chemistry of the Department of Agriculture.

THE CULTURE SOLUTION.

Many readers of these pages who are not bacteriologists will be interested in knowing the character of the solution which is used for testing the nitrifying vitality of the ferments in the soil. A solution which we have found very useful for this purpose is composed of the following constituents: Potassium phosphate, 1 gram; magnesium sulphate, half a gram; ammonium sulphate, two-tenths gram; calcium chloride, a trace, and calcium carbonate in excess of the amount which will be necessary to combine with all the nitric acid produced from the ammonium sulphate present. The above quantities of materials are dissolved or suspended in 1 liter (about 1 quart) of water, and one-tenth of this volume is used for each culture solution. This quantity is placed in an Erlenmeyer flask, which is then sterilized, after stoppering with cotton, by being kept at the temperature of boiling water for an hour on three successive days. The flask itself, before using, should be thoroughly sterilized by heating to 300° F. for an hour.

The calcium carbonate employed in the above culture solution should not be prepared by finely grinding marble or chalk, but in a chemical way by precipitation. It is best thoroughly sterilized separately and then added to the flask immediately before seeding. The sterilized spoon which is used for seeding holds, approximately, half a gram of the soil. This spoon is filled from the contents of one of the freshly opened sample tubes, underneath a glass hood, the plug of cotton is lifted from the sterilized flask, and the contents of the spoon quickly introduced and the plug of cotton replaced. While the above details are well known to the practical bacteriologist, they are not appreciated, as a rule, by the general reader. From the numerous inquiries concerning this process which have been received at the Department it is believed that the above brief outline of the method of procedure of securing samples of soil and seeding sterilized solutions therewith will be useful.

NOTING THE PROGRESS OF NITRIFICATION.

It will be seen from the above description that the object of the tests in question is to determine the activity and strength of the nitrous and nitric organisms alone, inasmuch as the process begins with an ammoniacal salt. At the end of five days from the time of the first seeding a portion of the solution is withdrawn in a sterilized pipette for the purpose of determining whether or not the process of nitrification has commenced; and if so, to what extent it has proceeded. This may be accomplished by either determining whether

any ammonia have been destroyed or whether any nitrous or nitric acids have been produced. These processes are of a purely chemical, technical nature and therefore would not be properly described in this place. In the case of an active and fertile soil the nitrifying process begins promptly, and as a rule continues with unabated vigor until the whole of the nitrogen present in the ammonium salt is converted into nitric acid. In very favorable circumstances this object will be accomplished in about six weeks. When the organisms in the sample are few in number or deficient in vitality, the nitrification does not begin for a long time, and then goes on with great slowness. By tracing the progress of the fermentation, as described above, it is seen how easy it is to compare various samples of soil in respect of their nitrifying power. If after four or five weeks no trace of nitrification has been found, the soils are regarded as being practically deficient in nitrifying ferments. This often happens with samples taken at a depth of 3 or more feet, or even in the case of surface soils or others subjected to conditions inimical to fermentative life.

REPRESENTATION OF THE DATA OBTAINED.

In the actual work which has been done in this Department to follow the progress of nitrification in culture solutions, it has been found convenient to determine the rate of the fermentative change by the determination of the nitrous and nitric acids produced. It is evident that in the process of fermentation three cases may arise. In the first place, the nitrous fermentation may occur first, and after its completion the nitric may follow it. This is a condition which evidently would rarely arise, and could only occur when the nitrous ferment was present in such a predominating quantity as to subdue and restrain the vitality of the nitric ferment. In the second place, the two fermentations could go on synchronously, and in this case the solution when tested would never contain more than the merest trace of nitrous acid. This condition of affairs would only occur when the two ferments were present in about equal numbers and endowed with equal vitality. In the third place, and this is the one which commonly occurs, the two fermentations go on synchronously, but at first the nitrous fermentation is more vigorous, so that there may be a considerable accumulation of nitrous acid in the solution. After a few weeks the nitric fermentation begins to gain in vitality by reason of the fact that the raw material on which the nitrous ferment worked has become nearly exhausted. The quantity of nitrous acid, therefore, which was at first formed would gradually begin to disappear, and finally, if the examination be continued long enough, be reduced to zero at or before the time when the total amount of nitrogen present would be converted into nitric acid.

In order to represent the progress of the fermentation, it has been found most convenient to use the graphic form of illustration. The

method of doing this is illustrated in the accompanying chart (fig. 1), showing the progress of nitrification in a sample of soil taken at a depth of 15 inches below the surface on the 27th of April, 1895, at the Canebrake station in Alabama. The culture solution was seeded with a sample of this soil on the 3d of May and the progress of nitrification is represented in the chart. The figures in the perpendicular column on the left represent the parts per million of nitrous or nitric acid. The continuous line represents the sum of the nitrous and nitric acids. The dotted line represents the nitrous acid in the solution. At any given time the actual amount of nitric acid present can be

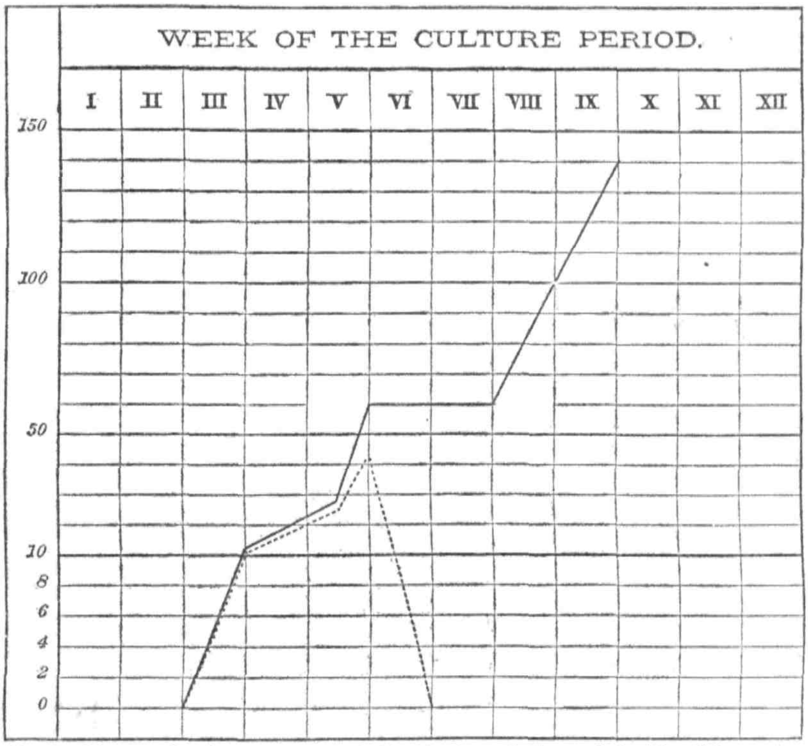

FIG. 1.—Diagram showing progress of nitrification in a solution seeded with soil ferments.

found by taking the difference between the continuous and dotted lines. Thus, at the end of the fifth week it is seen that there were nearly four parts of nitric acid present per million. The diagram shows that no action took place during the first two weeks after seeding. During the third week there was a vigorous evolution of nitrous acid, with only a trace of nitric acid. During the fourth week, attending a depression of temperature, the bacterial action was less active. During the fifth week both the nitrous and nitric organisms were active, attending a considerable rise of temperature. After the fifth week the nitrous acid began rapidly to disappear, being

converted into nitric acid. The horizontal position, however, of the continuous line shows that no additional nitrous acid was formed from the ammonia during the sixth week. During the seventh week there was no activity either of the nitrous or the nitric ferment. During the eighth and ninth weeks both ferments were again active, the nitrous acid being converted into nitric as soon as formed.

The second diagram (fig. 2) gives the variations in temperature of the closet where the nitrification took place during the whole time of observation. The upper line represents the maximum and the lower the minimum temperatures at the time mentioned. It will be seen by comparing the two diagrams that there is in general quite a marked agreement between the rate of nitrification and the degree of temperature. This is shown by the slow rate of nitrification during the third and fourth weeks and the rapid rate during the fifth week.

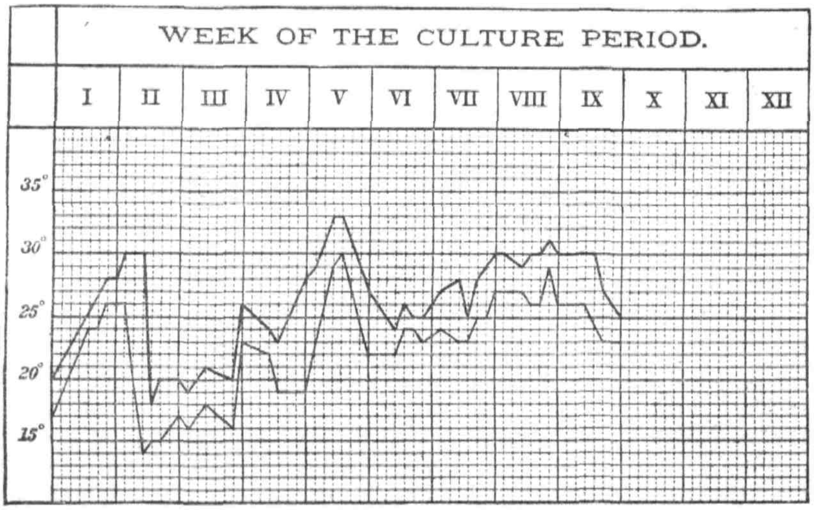

FIG. 2.—Diagram showing relation of temperature to rate of nitrification.

It is evident that many conditions beyond the control of the operator may serve to render the observations upon the rate of nitrification somewhat unreliable, but in general the data of nitrification properly ascertained will give an unerring insight into the character of a soil as affecting its ability to furnish nitrogen to the growing plant, and hence to that extent to the degree of its fertility.

PREPARATION OF PURE CULTURES.

It is evident from an inspection of the processes mentioned above that the ferments which are obtained in the culture solutions are not confined to the nitrous and nitric organisms. All the ferments which the sample of soil may have contained of every description suited to grow in the culture solution employed will be developed. The

solution, therefore, after the nitrification is complete, contains not only the nitrous and nitric microorganisms, but also all the other bacteria contained in the original sample capable of growing in the environment provided. It is probable that in different parts of the country and at different latitudes the species of nitrifying ferment may vary, and therefore it is of great importance to continue the examination of these bacteria until pure cultures are obtained. The methods of securing these are so technical and of so purely a bacteriological nature as to exclude them from description here. It will be sufficient to say that these pure cultures are obtained by seeding new cultures directly from the solutions obtained in the nitrifications produced by the soils as described. This work is continued until all the disturbing bacteria are eliminated, and there are left only those which will produce under favorable circumstances the nitrous and nitric fermentations alone.

SUMMARY.

1. Conclusions which are easily derived from the above data are that the soil is not merely dead, inert matter, but, on the contrary, in the highest degree a living organism. It contains numerous ferments which in their activity either favor or restrain the growth of crops. It is the part of scientific agriculture to determine, in so far as possible, the laws which govern the evolution of both of these forms of bacteria for the purpose of securing the greatest activity of the beneficial organisms and the least activity of the inimical ones.

2. The bacteria which provide nitrogenous food for plants are of three great classes. One of these exerts its activity only on organic nitrogen or the nitrogen contained in the humus of the soil. The second class is developed symbiotically with the growing plants, herding in colonies upon their rootlets, and securing in their vital activity an oxidation of the free nitrogen of the atmosphere. The third class of organisms and the one least known appears to have the ability, in an independent form of life and without the aid of plant vitality, to secure the oxidation of atmospheric nitrogen. The first of the classes mentioned above is itself separated into three divisions comprising the organisms which produce ammonia, nitrous and nitric acids, respectively.

3. Many crops, such as the cereals, have no ability in themselves to increase the stores of nitrogen in the soil. Such crops may be grown for many years upon the same field, in which case the nitrogenous supply of the field will at first be rapidly diminished, with a corresponding decrease in the crop itself. Finally a time will come when a certain minimum crop will be produced apparently for an indefinite time, varying only under seasonal influences.

4. Other vegetables, especially leguminous plants, favor the development of the organisms which are capable of oxidizing free nitrogen and thereby tend to increase the supply of available nitrogenous

matter. These crops, however, together with certain root crops, can not be grown successfully without rotation, and all crops are benefited by a judicious succession.

5. The summer fallowing of land is highly injudicious, and especially if the field be left bare through the winter. The nitrates which are formed by the activity of the nitrifying organisms in such cases are easily washed out by heavy rains and lost to agricultural uses perhaps for thousands of years.

6. Late autumnal plowing, after the activity of the nitrifying organisms has practically ceased, may prove beneficial, especially to some crops, by exposing the soil to the decomposing effects of the frosts of winter.

7. In past geological ages vast quantities of nitrogenous matter have been oxidized and stored, in the form of nitrates, and these stores are now available for the uses of agriculture.

Nitric acid, in the form of nitrates, should be employed only as a temporary fertilizer in order to improve the fertility of the soil to such an extent as to make profitable the growing of leguminous crops. The continued use of nitrates for fertilizing purposes deprives the nitrifying organisms of their functional activity, and hence tends to diminish their numbers and to enfeeble their work. Nitrates should only be applied in small quantities at a time, sufficient to meet the immediate demands of the crop. It is better to apply the dressing of nitrates at two or three different times during the growth of the crop, rather than to use it all at once.

8. The use of sewage for fertilizing purposes is not to be commended because of the danger of contaminating the soil with pathogenic ferments, which may subsequently infect the health of man and beast. These ferments may attach themselves to vegetables and thus enter the animal organism, or they may remain with a suspended vitality for an indefinite period in the soil and awaken to pernicious activity when a favorable environment is secured.

9. The study of the nitrifying organisms in the soil and their culture and isolation will in the end prove of great benefit to practical agriculture by showing the method in which favoring organisms can be fostered and the activity of the inimical organisms reduced to a minimum.

ORIGIN, VALUE, AND RECLAMATION OF ALKALI LANDS.

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OCCURRENCE AND CHARACTERISTICS OF ALKALI SOILS.

Alkali lands must be pointedly distinguished from the salty lands of sea margins or marshes, from which they differ both in their origin and essential nature. Marsh lands derive their salts from sea water that occasionally overflows them, and the salts which impregnate them are essentially "sea salts;" that is, common salt, together with bittern, Epsom salt, etc. Very little of what would be useful to vegetation or desirable as a fertilizer is contained in the salts impregnating such soils; and they are by no means always intrinsically rich in plant food, but vary greatly in this respect.

Alkali lands bear no definite relation to the sea; they are mostly remote from it or from any former sea bed, so that they have sometimes been designated as "terrestrial salt lands." Their existence is definitely traceable to climatic conditions alone. They are the natural result of a light rainfall, insufficient to leach out of the land the salts that always form in it by the progressive weathering of the rock powder of which all soils largely consist. Where the rainfall is abundant, that portion of the salts corresponding to "sea salts" is leached out into the bottom water, and with this passes through springs and rivulets into the country drainage, to be finally carried to the ocean. Another portion of the salts formed by weathering, however, is partially or wholly retained by the soil; it is that portion chiefly useful as plant food.

It follows that when, in consequence of insufficient rainfall, all or most of the salts are retained in the soil, they will contain not only the ingredients of sea water, but also those useful to plants. In rainy climates a large portion, even of the latter, is leached out and carried away. In extremely arid climates their entire mass remains in the soils; and, being largely soluble in water, evaporation during the dry season brings them to the surface, where they may accumulate to such an extent as to render ordinary useful vegetation impossible, as is seen in "alkali spots," and sometimes in extensive tracts of "alkali desert."

In looking over a rainfall map of the globe we see that a very considerable portion of the earth's surface has deficient rainfall, the

latter term being commonly meant to imply any annual average less than 20 inches (500 millimeters). The arid region thus defined includes, in North America, most of the country lying west of the one hundredth meridian up to the Cascade Mountains, and northward beyond the line of the United States; southward, it reaches far into Mexico, including especially the Mexican plateau. In South America it includes all the Pacific Slope (Peru and Chile) south to Araucania; and eastward of the Andes, the greater portion of the plains of western Brazil and Argentina. In Europe only a small portion of the Mediterranean border is included; but the entire African coast belt opposite, with the Saharan and Libyan deserts, Egypt, and Arabia are included therein, as well as a considerable portion of South Africa. In Asia, Asia Minor, Syria (with Palestine), Mesopotamia, Persia, and northwestern India up to the Ganges, and northward, the great plains or steppes of central Asia eastward to Mongolia and western China fall into the same category, as does also a large portion of the Australian continent.

Over these vast areas alkali lands occur to a greater or less extent, the exceptions being the mountain regions and adjacent lands on the side exposed to the prevailing winds. It will therefore be seen that the problem of the utilization of alkali lands for agriculture is not of local interest only, but is of world-wide importance. It will also be noted that many of the countries referred to are those in which the most ancient civilizations have existed in the past, but which at present, with few exceptions, are occupied by semicivilized people only. It is doubtless from this cause that the nature of alkali lands has until now been so little understood that even their essential distinctness from the sea-border lands has been but lately recognized in full. Moreover, the great intrinsic fertility of these lands has been very little appreciated, their repellent aspect causing them to be generally considered as waste lands.

This aspect is essentially due to their natural vegetation being in most cases confined to plants useless to man, commonly designated as "saline vegetation," of which but little is usually relished by cattle. Notable exceptions to this rule occur in Australia and Africa, where the "saltbushes" of the former and the "karroo" vegetation of the latter form valuable pasture grounds. Apart from these, however, all efforts to find culture plants for these lands generally acceptable, or at least profitable, in their natural condition, have not been very successful.

HOW PLANTS ARE INJURED BY ALKALI.

When we examine plants that have been injured by alkali, we will almost invariably find that the damage has been done near the base of the trunk, or root crown; very rarely at any considerable depth in the soil itself. In the case of green herbaceous stems, the bark is found to have turned to a brownish tinge for half an inch or more,

so as to be soft and easily peeled off. In the case of trees, the rough bark is found to be of a dark, almost black, tint, and the green layer underneath has, as in the case of an herbaceous stem, been turned brown to a greater or less extent. In either case the plant has been practically "girdled," the effect being aggravated by the diseased sap poisoning more or less the whole stem and roots. The plant may not die, but it will be quite certain to become unprofitable to the grower.

The fact that in cultivated land the injury is almost invariably found to occur near the surface of the soil, concurrently with the well-known fact that the maximum accumulation of salts at the surface is always found near the end of the dry season, indicates clearly that this accumulation is due to evaporation at the surface. The latter is often found covered with a crust consisting of earth cemented by the crystallized salts, and later in the season with a layer of whitish dust resulting from the drying out of the crust first formed. It is this dust which becomes so annoying to the inhabitants and travelers in alkali regions, when high winds prevail, irritating the eyes and nostrils and parching the lips.

EFFECTS OF IRRIGATION.

One of the most annoying and discouraging features of the cultivation of lands in alkali regions is that, although in their natural condition they may show but little alkali on their surface, and that mostly in limited spots, usually somewhat depressed below the general surface, these spots are found to enlarge rapidly as irrigation is practiced; for since alkali salts are the symptoms and result of insufficient rainfall, irrigation is a necessary condition of agriculture wherever they prevail. Under irrigation neighboring spots will oftentimes merge together into one large one, and at times the entire area, once highly productive and perhaps covered with valuable plantations of trees or vines, will become incapable of supporting useful growth. This annoying phenomenon is popularly known as "the rise of the alkali" in the western United States, but is equally well known in India and other irrigation regions.

WICK ACTION OF THE SOIL.

The process by which the salts rise to the surface is the same as that by which oil rises in a wick. The soil being impregnated with a solution of the alkali salts, and acting like the wick, the salts naturally remain behind on the surface as the water evaporates, the process only stopping when all the moisture in the soil is exhausted. We thus not infrequently find that after an unusually heavy rainfall there follows a heavier accumulation of alkali salts at the surface, while a light shower produces no perceptible permanent effect. We are thus taught that within certain limits the more water evaporating

during the season the heavier will be the rise of the alkali. The limitation is, clearly, that the water must not be so abundant as to leach the salts through the soil and subsoil into the subdrainage.

DETERMINATION OF THE DISTRIBUTION OF THE ALKALI SALTS.

In order to gain a basis for the possible means of reclaiming alkali lands, it is evidently necessary to determine by direct observation the manner in which the salts are distributed in the soils under different conditions. This can be done by sampling the soil at short intervals of depth and leaching out and analyzing each sample separately. While this involves a great deal of work, it is manifestly the only conclusive method. It requires the sampling of the soil under at least three different conditions, as shown below.

A series of such investigations has been carried out at the California Experiment Station during the years 1894 and 1895, with samples taken in or near the substation near Tulare, Cal., with the results as given below.

COMPOSITION OF ALKALI SALTS.

Before proceeding to discuss the results of these investigations, it is necessary to consider the composition of the alkali salts in a general manner. Broadly speaking, it may be said that, all the world over, they consist of three chief ingredients, namely, common salt, Glauber salt (sulphate of soda), and salsoda or carbonate of soda. The latter causes what is popularly known as "black alkali," from the black spots or puddles seen on the surface of lands tainted with it, owing to the dissolution of the soil humus, while the other two salts constitute "white alkali," which is known to be very much milder in its effect on plants than the black. In most cases all three are present, and all may be considered as practically valueless or noxious to plant growth. With them, however, there are almost always associated, in varying amounts, sulphate of potash, phosphate of soda, and nitrate of soda, representing the three elements—potassium, phosphorus, and nitrogen—upon the presence of which in the soil, in available form, the welfare of our crops so essentially depends and which we aim to supply in fertilizers. The potash salt is usually present to the extent of from 5 to 20 per cent of the total salts; phosphate, from a fraction to as much as 4 per cent; the nitrate, from a fraction to as much as 20 per cent. In black alkali the nitrate is usually low, the phosphate high; in the white the reverse is true.

It is thus clear that if we were to make a rule of reclaiming alkali lands by leaching out the salts with abundance of irrigation water, we would get rid not only of the noxious salts, but also of those ingredients upon which productiveness primarily depends, and for which we pay heavily in fertilizers. This is evidently to be avoided, if possible.

Figs. 3 and 4 represent the condition of the salts in an "alkali spot" as found at the end of the dry season. The soil was sampled to the depth of 2 feet, at intervals of 3 inches each. The depths are entered in the vertical line to the left; the percentages of the total salts and of each of the principal ingredients are entered in decimal fractions of 1 per cent on horizontal lines running to the right, as indicated on the top line of the plate. Broken lines connecting the data in each case facilitate the understanding of the results. It is thus easy to see that at this time almost the entire mass of the salts was accumulated within the first 6 inches from the surface, while lower down the soil contained so little that few culture plants would be hurt by them.

Fig. 5 represents similarly the state of things in a natural soil alongside of the alkali spot, but in which the native vegetation of brilliant flowers develops annually without any hindrance from alkali. Samples were taken from this spot in March, near the end of the wet, and in September, near the end of the dry, season, and each series fully analyzed. There was scarcely a noticeable difference in the results obtained. It is seen in the figure that down to the depth of 15 inches there was practically no alkali found (0.035), and it was within

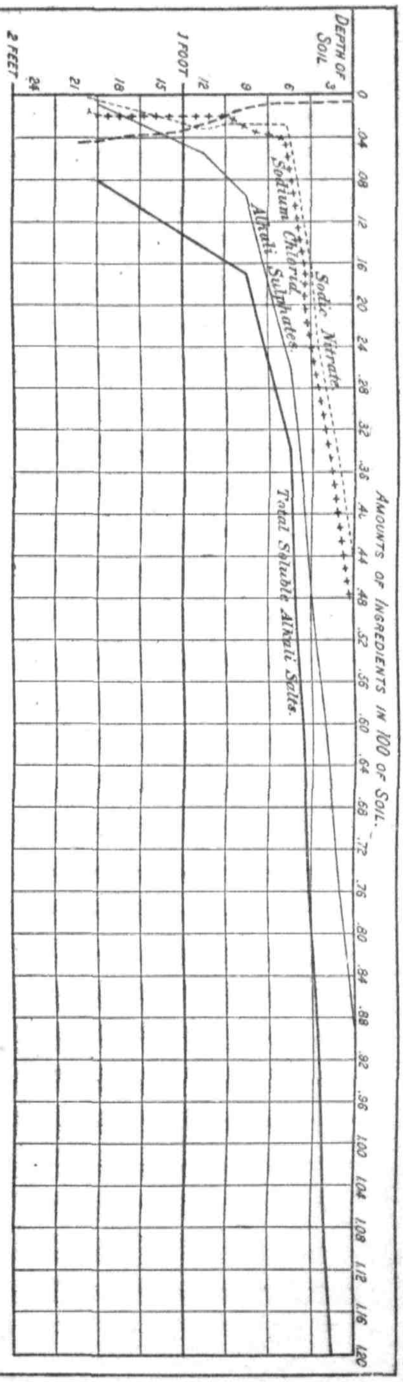

FIG. 3.—Diagram showing amount and composition of alkali salts at various depths in partially reclaimed alkali land, on which barley grew 4 feet high. Taken September, 1894. Tulare Experiment Station, California.

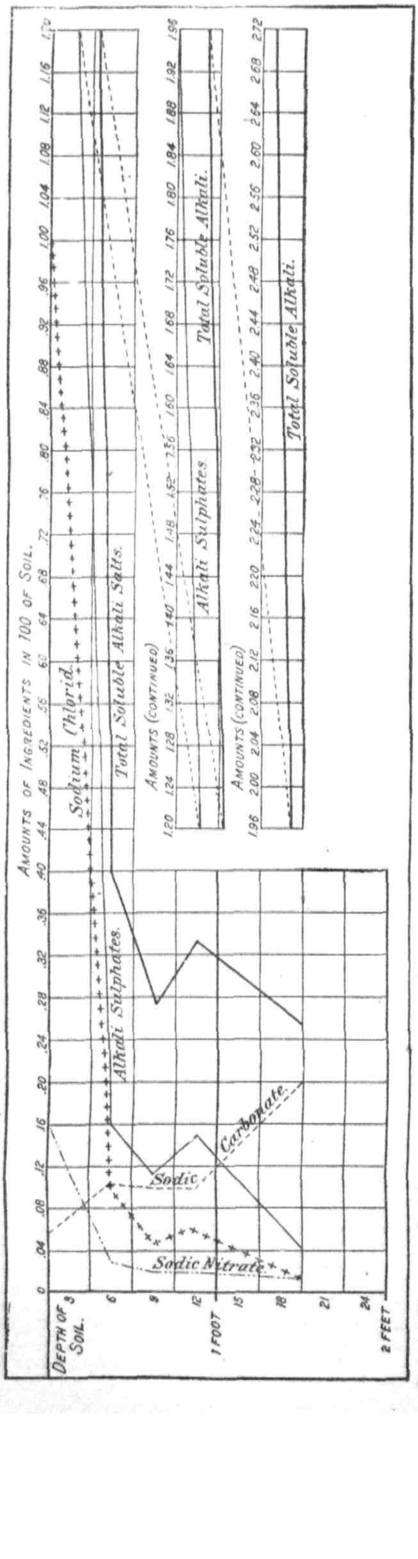

FIG. 4.—Diagram showing amounts and composition of alkali salts at various depths in alkali soil, on which barley would not grow. Taken September, 1894. Tulare Experiment Station.

these 15 inches of soil that the native plants mostly had their roots and developed their annual growth. But from that level downward the alkali rapidly increased, and reached a maximum at about 33 inches (0.529), decreasing rapidly thence until, at the end of the fourth foot in depth, there was not more alkali than within the first foot from the surface. In other words, the bulk of the salts had accumulated at the greatest depth to which the annual rainfall (7 inches) ever reaches, forming there a sheet of tough, intractable clay hardpan. The shallow-rooted native plants germinated their seeds freely on the alkali-free surface, their roots kept above the strongly charged subsoil, and through them and the stems and foliage all the soil moisture was evaporated by the time the plants died. Thus no alkali was brought up from below by evaporation. The seeds shed would remain uninjured and would again germinate the coming season.

It is thus that the luxuriant vegetation of the plains, dotted with occasional alkali spots, is maintained, the spots themselves being almost always depressions in which the rain water may gather, and where, in consequence of the increased evaporation, the noxious salts have risen to the surface and render impossible all but the most

resistant saline growth, particularly when, in consequence of maceration and fermentation in the soil, the formation of carbonate of soda (black alkali) has caused the surface to sink and become almost water-tight.

Fig. 6 shows the state of things after several years' cultivation with irrigation on the same land as in the last figure. A crop of barley 4 feet high was growing on the land at the time. It is easy to see that here the condition of the soil is intermediate between the two preceding figures. The irrigation water had dissolved the alkali of the subsoil and the abundant evaporation had brought it nearer the surface; but the shading by the barley crop and the evaporation of the moisture through its roots and leaves had prevented the salts from reaching the surface in such amounts as to injure the crop, although the tendency to rise is clearly shown.

Ten feet from this spot was bare alkali ground on which barley had refused to grow. The result of its examination is shown in fig. 7, proving it to contain a somewhat larger proportion (one-fifth more) of alkali salts, and in these a larger relative proportion of carbonate (salsoda). The cause of the latter fact was that the gypsum used had not been sufficient to neutralize as large a proportion of the black alkali as in fig. 6, the same amount having been used on both places. Thus the seed was mostly destroyed before germination, and of the few seedlings none lived beyond the fourth leaf. On the ground represented by fig. 3 previous treatment with gypsum had so far diminished the salsoda that the grain germinated freely and a very good crop of barley was harvested there without irrigation. The same season grain crops were almost a failure on alkali-free land in the same region. In connection with this result it should be noted *as a general fact that alkali lands always retain a certain amount of* moisture perceptible to the hand during the dry season, and that this moisture can be utilized by crops, so that at times when crops fail on nonalkaline land, good ones are obtained where a slight taint of alkali exists in the soil. Striking examples of this fact occur in the Spokane country within the great bend of the Columbia River, in the State of Washington; and the same is illustrated by the luxuriant growth of weeds on the margin of alkali spots just beyond the limit of corrosive injury.

While the phenomena of alkali lands as outlined above undoubtedly represent the vastly predominant conditions on level lands, yet there are exceptions due to surface conformations and to the local existence of sources of alkali salts outside of the soil itself. Such is the case where salts ooze out of strata cropping out on hillsides, as is the case at some points in the San Joaquin Valley in California and in parts of Colorado and Wyoming; also where, as in Hungary, saline clays underlie within reach of surface evaporation.

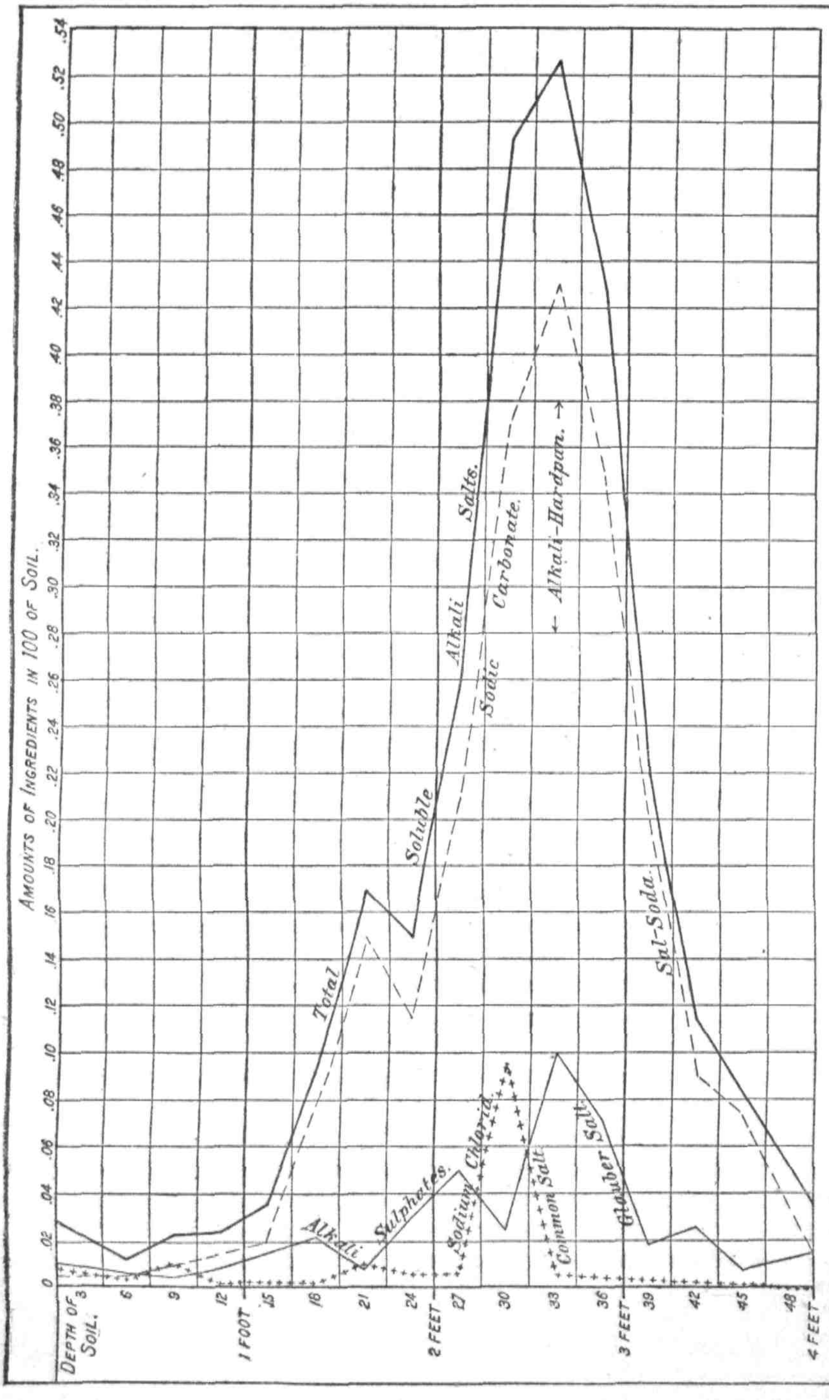

FIG. 5.—Diagram showing amounts and composition of alkali salts at various depths in alkali land, unirrigated. Taken March 1895. Tulara Experiment Station

Again, it not infrequently happens that in sloping valleys or basins, where the central (lowest) portion receives the salts leached out of the soils of the adjacent slopes, we find belts of greater or less width in which the alkali impregnation may reach to the depth of 10 or 12 feet, usually within more or less definite layers of calcareous hard-pan, likewise the outcome of the leaching of the valley slopes. Such

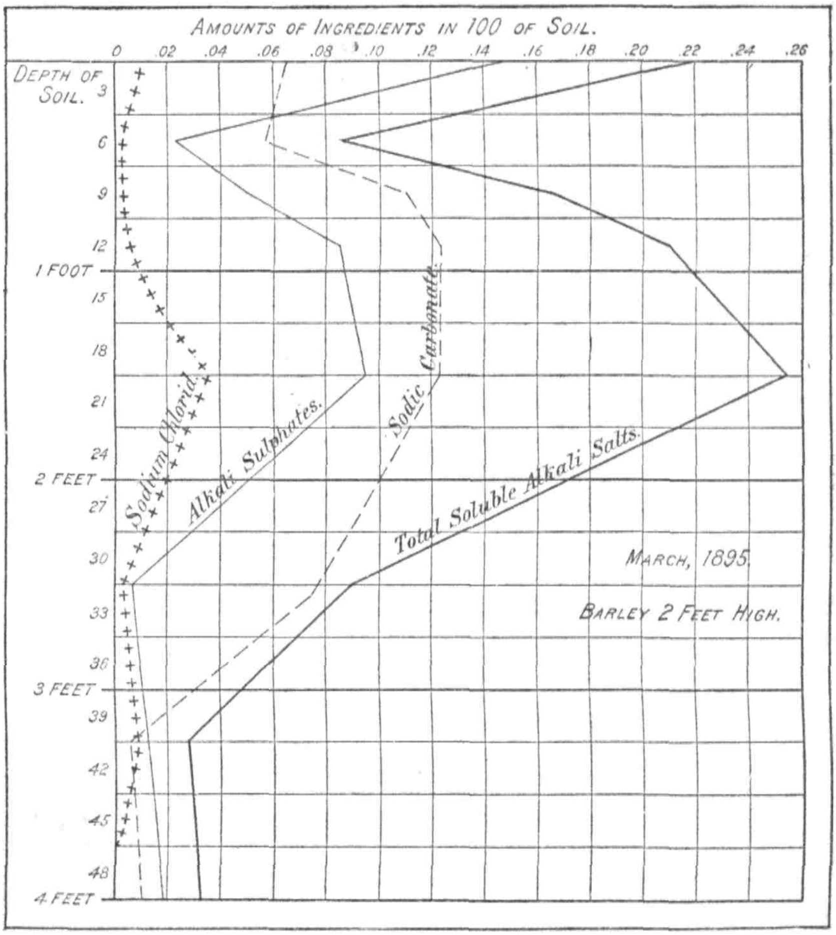

FIG. 6.—Diagram showing amounts and composition of alkali salts at various depths in partly reclaimed alkali land. Tulare Experiment Station.

areas, however, are usually quite limited, and are, of course, scarcely reclaimable without excessive expenditure, the more as they are often underlaid by saline bottom water. In these cases the predominant saline ingredient is usually common salt, as might be expected and as is exemplified on a large scale in the Great Salt Lake of Utah and in the ocean itself.

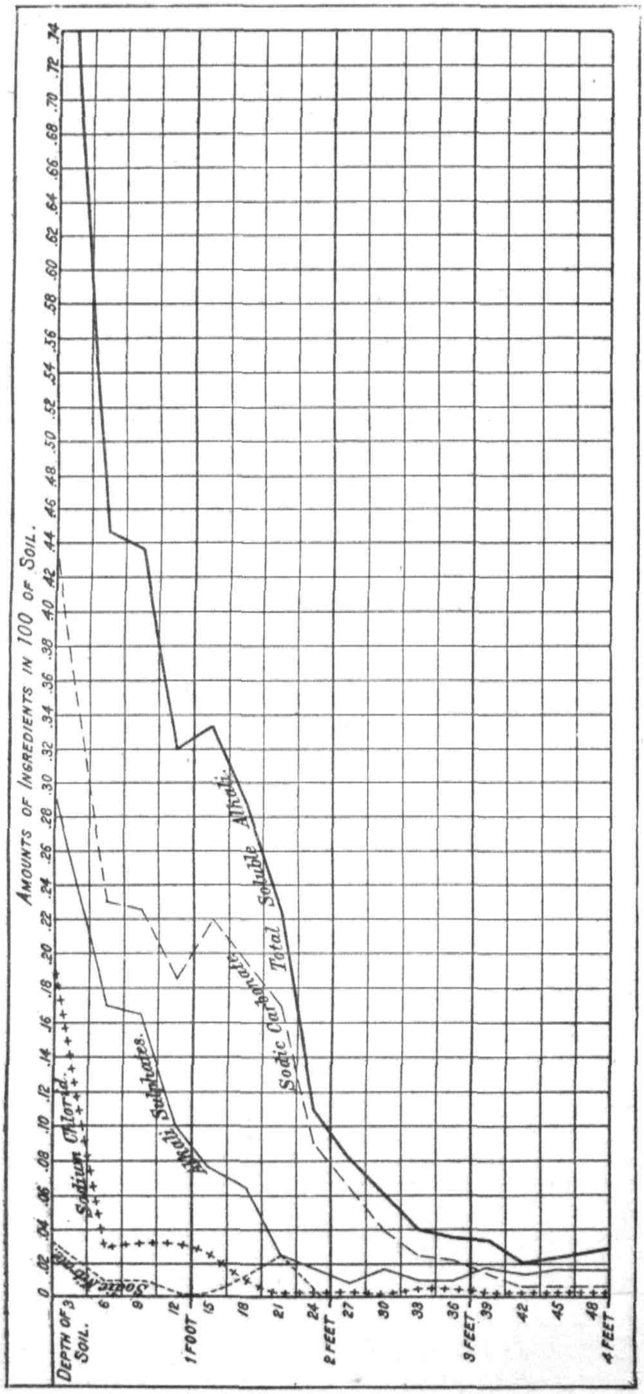

FIG. 7.—Diagram showing amounts and composition of alkali salts at various depths in bare alkali land, where barley would not grow, irrigated. Taken September, 1894. Tulare Experiment Station.

Summing up the conclusions from the foregoing observations and considerations, we find that—

(1) The amount of soluble salts in alkali soils is usually limited; they are not supplied in indefinite quantities from the bottom water below. These salts have essentially been formed by weathering in the soil layer itself.

(2) The salts move up and down within the upper 4 or 5 feet of the soil and subsoil, following the movement of the moisture, descending in the *rainy season to the limit of the annual moistening as a maximum*, and then reascending or not according as surface evaporation may demand. At the end of the dry season, in untilled irrigated land, the entire mass of salts may be within 6 or 8 inches of the surface.

(3) The injury to vegetation is caused mainly or wholly within a few inches of the surface by the corrosion of the bark, usually near the root crown. This corrosion is strongest when carbonate of soda (salsoda) forms a large proportion of the salts; the soda then also dissolves the vegetable mold and causes blackish spots in the soil, popularly known as *black alkali*.

(4) The injury caused by carbonate of soda is aggravated by its action in puddling the soil so as to cause it to lose its flaky condition, rendering it almost or quite untillable. It also tends to form in the depths of the soil layer a tough, impervious hardpan, which yields neither to plow, pick, nor crowbar. Its presence is easily ascertained by means of a pointed steel sounding rod.

(5) While alkali lands share with other soils of the arid region the advantage of unusually high percentages of plant food in the insoluble form,[1] they also contain, alongside of the noxious salts, considerable amounts of soluble plant food. When, therefore, the action of the noxious salts is done away with, they should be profusely and lastingly productive; particularly as they are always naturally somewhat moist in consequence of the attraction of moisture by the salts, and are therefore less liable to be injured from drought than the same soils when free from alkali.

UTILIZATION AND RECLAMATION OF ALKALI LANDS.

The most obvious mode of utilizing alkali lands is to occupy them with useful plants that are not affected by the noxious salts. Unfortunately, as has already been stated, but few such crops of general utility, especially for the commercial and labor conditions of this country, have as yet been found. Practically the most important problem is to render these lands available for our ordinary cultures; and for this reason this part of the subject will be considered first.

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[1] See Bulletin No. 3 of the United States Weather Bureau, 1892.

COUNTERACTING EVAPORATION.

Since evaporation of the soil moisture at the surface is what brings the alkali salts to the level where the main injury to plants occurs, it is obvious that evaporation should be prevented as much as possible. This is the more important, as the saving of soil moisture, and therefore of irrigation water, is attainable by the same means.

Three methods for this purpose are usually practiced by farmers and gardeners, viz, shading, mulching, and the maintenance of loose tilth in the surface soil to such depth as may be required by the climatic conditions.

As to mulching, it is already well recognized in the alkali regions of California as an effective remedy in light cases. Fruit trees are frequently thus protected, particularly while young, after which their shade alone may (as in the case of low-trained orange trees) suffice to prevent injury. The same often happens in the case of low-trained vines, small fruit, and vegetables. Sanding of the surface to the depth of several inches was among the first attempts in this direction; but the necessity of cultivation, involving the renewal of the sand each season, renders this a costly method. Straw, leaves, and manure have been more successfully used; but even these, unless employed for the purpose of fertilization, involve more expense and trouble than the simple maintenance of very loose tilth of the surface soil throughout the dry season, a remedy which, of course, is equally applicable to field crops, and is in the case of some of these—e. g., cotton—a necessary condition of cultural success everywhere. The wide prevalence of "light" soils in the arid regions, from causes inherent in the climate itself,[1] renders this condition of relatively easy fulfillment.

Aside, however, from the mere prevention of surface evaporation, another favorable condition is realized by this procedure, namely, the commingling of the heavily salt-charged surface layers with the relatively nonalkaline subsoil. Since in the arid regions the roots of all plants retire farther from the surface because of the deadly drought and heat of summer, it is usually possible to cultivate deeper than could safely be done with growing crops in humid climates. Yet, even here, the maxim of "deep preparation and shallow cultivation" is put into practice with advantage, only changing the measurements of depth to correspond with the altered climatic conditions. Thus, while in the eastern United States 4 inches is the accepted standard of depth for summer cultivation to preserve moisture without injury to the roots, that depth must in the arid region frequently be doubled in order to be effective, and will even then scarcely touch a living root in orchards and vineyards, particularly in unmanured and unirrigated land.

A glance at fig. 3 (p. 107), will show the great advantage of extra

[1] See Bulletin No. 3 of the United States Weather Bureau, p. 17.

deep preparation in commingling the alkali salts accumulated near the surface with the lower soil layers, diffusing the salts through 12 instead of 6 inches of soil mass. This will in very many cases suffice to render the growth of ordinary crops possible if, by subsequent frequent and thorough cultivation, surface evaporation, and with it the reascent of the salts to the surface, is prevented. A striking example of the efficacy of this mode of procedure was given at the Tulare station, where a portion of a very bad alkali spot was trenched to the depth of 2 feet, throwing the surface soil to the bottom. The spot thus treated produced excellent wheat crops for a few years—the time it took the alkali salts to reascend to the surface.

It should therefore be kept in mind that whatever else is done toward reclamation, deep preparation and thorough cultivation must be regarded as prime factors for the maintenance of production on alkali lands.

The efficacy of shading, already referred to, is strikingly illustrated in the case of some field crops which, when once established, will thrive on fairly strong alkali soil, provided that a good thick "stand" has once been obtained. This is notably true of the great forage crop of the arid region, alfalfa, or lucern. Its seed is extremely sensitive to black alkali, and will decay in the ground unless protected against it. But when once a full stand has been obtained, the field may endure for many years without a sign of injury. Here two effects combine, viz, the shading, and the evaporation through the deep roots and abundant foliage, which alone prevents, in a large measure, the ascent of the moisture to the surface. The case is then precisely parallel to that of the natural soil (see fig. 4), except that, as irrigation is practiced in order to stimulate production, the sheet of alkali hardpan will be dissolved and its salts spread through the soil more evenly. The result is that so soon as the alfalfa is taken off the ground and the cultivation of other crops is attempted, an altogether unexpectedly large amount of alkali comes to the surface and greatly impedes, if it does not altogether prevent, the immediate planting of other crops. Shallow-rooted annual crops that give but little shade, like the cereals, while measurably impeding the rise of the salts during their growth, frequently allow of enough rise after harvest to prevent reseeding the following season.

TOTAL AMOUNT OF SALTS COMPATIBLE WITH ORDINARY CROPS.

Since the amount of alkali that reaches the surface layer is largely dependent upon the varying conditions of rainfall or irrigation, and surface evaporation, it is difficult to foresee to what extent that accumulation may go, unless we know the total amount of salts present that may be called into action. This can be ascertained by a summation of the results obtained and shown in the diagrams for each layer, but more readily by the examination of one sample

representing the average of the entire soil column of 4 feet. By calculating the figures so obtained to an acre of ground, we can at least approximate the limits within or beyond which crops will succeed or perish. Applying this procedure to the cases represented in the diagrams, and estimating the weight of the soil per acre-foot at 4,000,000 pounds, we find in the land on which barley refused to grow the figures 32,470 and 43,660 pounds of total salts per acre, respectively, corresponding to 0.203 per cent for the first figure (the second, representing only the 2 surface feet, is not strictly comparable). For the land on which barley gave a full crop, we find for the May sample 25,550 pounds, equivalent to 0.159 per cent for the whole soil column of 4 feet. It thus appears that for barley the limits of tolerance lie between the above two figures, which might, of course, have been obtained equally well from an average sample of the 4-foot column by making a single analysis. It should be noted that in this case a full crop of barley was grown, even when the alkali consisted of fully one-half of the noxious carbonate of soda, proving that it is not necessary in every case to neutralize the entire amount of that salt by means of gypsum, which, in the present case, would have required about 9½ tons of gypsum per acre—an almost prohibitory expenditure.

CHEMICAL ANTIDOTES.

To the chemist it is readily apparent that of the three sodium salts that usually constitute the bulk of "alkali" only the carbonate of soda is susceptible of being materially changed by any agent that can practically be applied to land. So far as we know, the salt of sodium least injurious to ordinary vegetation is the sulphate, commonly called Glauber salt, which ordinarily forms the chief ingredient of white alkali. Thus barley is capable of resisting about five times more of the sulphate than of the carbonate, and quite twice as much as of common salt. Since the maximum percentage that can be resisted by plants varies materially with the kind of soil, it is difficult to give exact figures save with respect to particular cases. For the sandy loam of Tulare station the maximum for cereals may be approximately stated to be one-tenth of 1 per cent for salsoda, a fourth of 1 per cent for common salt, and from forty-five to fifty one-hundredths of 1 per cent for Glauber salt, within the first foot from the surface. For clay soils the tolerance is markedly less, especially as regards the salsoda, since in their case the injurious effect on the tilling qualities of the soil, already referred to, is superadded to the corrosive action of that salt.

Since, then, so little carbonate of soda suffices to render soils uncultivable, it frequently happens that its mere transformation into the sulphate is sufficient to remove all stress from alkali. Gypsum (land plaster) is the cheap and effective agent to bring about this

transformation, provided water be also present. The amount required per acre will, of course, vary with the amount of salts in the soil, all the way from a few hundred pounds to several tons in the case of strong alkali spots; but it is not usually necessary to add the entire quantity at once, provided that sufficient be used to neutralize the alkali near the surface and enough time be allowed for the action to take place. In very wet soil this may occur within a few weeks; in merely damp soils, in the course of months; but usually the effect increases for years, as the salts rise from below.

The effect of gypsum on black alkali land is often very striking, even to the eye. The blackish puddles and spots disappear, because the gypsum renders the dissolved humus insoluble and thus restores it to the soil. The latter soon loses its hard, puddled condition and crumbles and bulges into a loose mass into which water now soaks freely, bringing up the previously depressed spots to the general level of the land. On the surface thus changed seeds now germinate and grow without hindrance; and as the injury from alkali occurs at or near the surface, it is usually best to simply harrow in the plaster, leaving the water to carry it down in solution. Soluble phosphates present are decomposed so as to retain finely divided but less soluble phosphates in the soil.

It must not be forgotten that this beneficial change may go backward if the land thus treated is permitted to be swamped by irrigation water or otherwise. Under the same conditions naturally white alkali may turn black. Of course, gypsum is of no benefit whatever on soils containing no salsoda, but only Glauber and common salt.

REMOVING THE SALTS FROM THE SOIL.

In case the amount of salts in the soil should be so great that even the change worked by gypsum is insufficient to render it available for useful crops, the only remedy left is to remove the salts partially or wholly from the land. Two chief methods are available for this purpose. One is to remove the salts, with more or less earth, from the surface at the end of the dry season, either by sweeping or by means of a horse scraper set so as to carry off a certain depth of soil. Thus sometimes in a single season one-third or one-half of the total salts may be got rid of, the loss of a few inches of surface soil being of little moment in the deep soils of the arid region.[1] The other method is to leach them out of the soil into the country drainage, supplementing by irrigation water what is left undone by the deficient rainfall.

It is not practicable, as many suppose, to wash the salts off the surface by a rush of water, as they instantly soak into the ground at the first touch. Nor is there any sensible relief from allowing the water to stand on the land and then drawing it off; in this case also the

[1] See Bulletin No. 3 of the United States Weather Bureau, p. 19.

salts soak down ahead of the water, and the water standing on the surface remains almost unchanged. In very pervious soils and in the case of white alkali the washing out can often be accomplished without special provision for underdrainage by leaving the water on the land sufficiently long. But the laying of regular underdrains greatly accelerates the work, and renders success certain.

An important exception, however, occurs in the case of black alkali in most lands. In this case either the impervious hardpan or (in the case of actual alkali spots) the impenetrability of the surface soil itself will render even underdrains ineffective unless the salsoda and its effects on the soil are first destroyed by the use of gypsum, as above detailed. This is not only necessary in order to render drainage and leaching possible, but is also advisable in order to prevent the leaching out of the valuable humus and soluble phosphates which are rendered insoluble (but not unavailable to plants) by the action of the gypsum. Wherever black alkali is found, therefore, the application of gypsum should precede any other efforts toward reclamation.

Trees and vines already planted may be temporarily protected from the worst effects of the black alkali by surrounding the trunks with gypsum or with earth abundantly mixed with it. Seeds may be similarly protected in sowing, and young plants in planting.

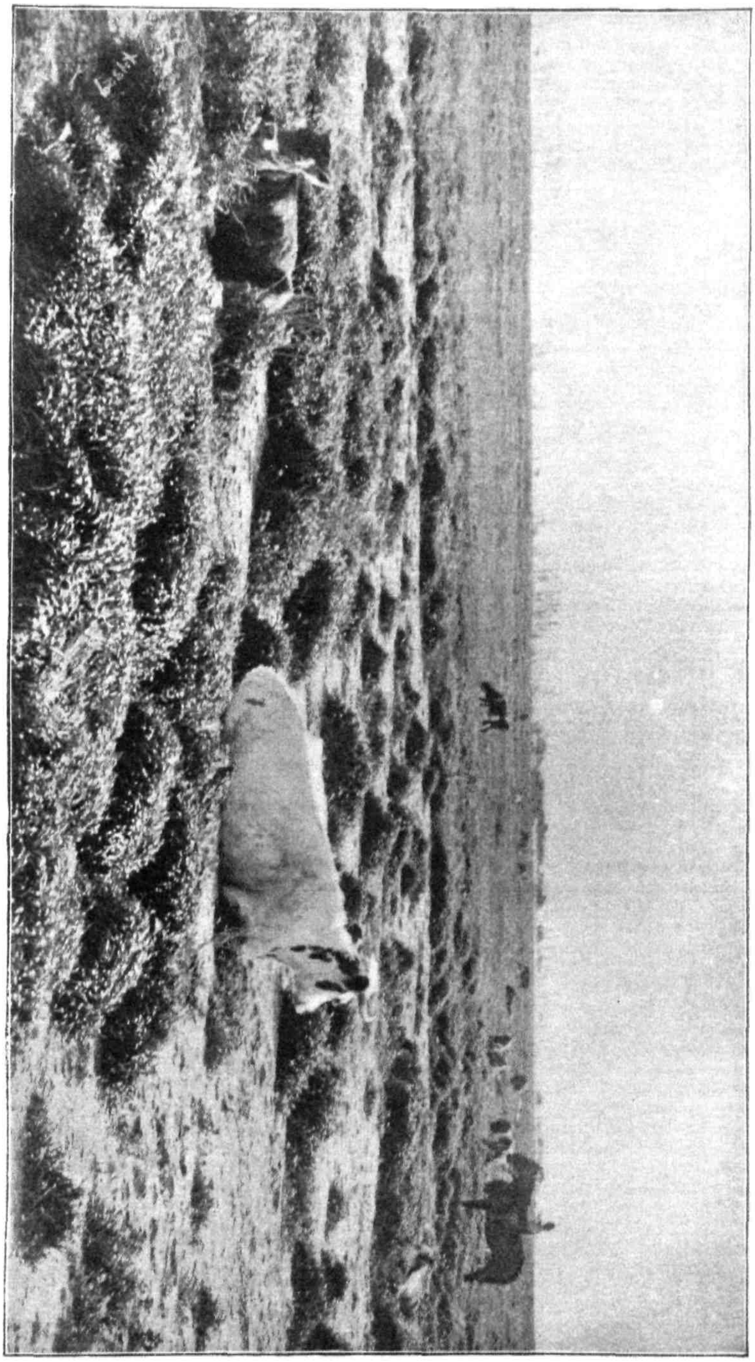
Another method for diminishing the amount of alkali in the soil is the cropping with plants that take up considerable amounts of salts. In taking them into cultivation, it is advisable to remove entirely from the land the salt growth that may naturally cover it, notably the greasewood (*Sarcobatus*), with its heavy percentage of alkaline ash (12 per cent). Crop plants adapted to the same object are mentioned farther on.

WILL IT PAY TO RECLAIM ALKALI SOILS?

This is a question naturally asked when considering the nature and expense of the operation involved, especially when the last resort—underdraining and leaching—has to be adopted.

Those familiar with the alkali regions are aware how often the occurrence of alkali spots interrupts the continuity of fields and orchards, of which they form only a small part, but enough to mar their aspect and cultivation. Their increase and expansion under irrigation frequently renders their reclamation the only alternative of absolute abandonment of the investments and improvements made, and from that point of view alone it is of no slight practical importance. Moreover, the occurrence of vast continuous stretches of alkali lands within the otherwise most eligibly situated portions of the irrigation region forms a strong incentive toward their utilization.

There is, however, a strong intrinsic reason pointing in the same direction, namely, the almost invariably high and lasting productiveness



ALKALI LANDS IN SAN JOAQUIN VALLEY, CALIFORNIA.

of these lands when once rendered available to agriculture. This is foreshadowed by the usually very heavy and luxuriant growth of native plants around the margins and between alkali spots (see Pl. II); that is, wherever the amount of injurious salts present is so small as not to interfere with the utilization of the abundant store of plant food which, under the peculiar conditions of soil formation in arid climates, remains in the land instead of being washed into the ocean. Extended comparative investigations of soil composition, as well as the experience of thousands of years in the oldest settled countries of the world, demonstrate this fact and show that so far from being in need of fertilization, alkali lands possess extraordinary productive capacity whenever freed from the injurious influence of the excess of useless salts left in the soil in consequence of deficient rainfall.

It does not, of course, follow that alkali lands are good lands for farmers of limited means to settle upon. On the contrary, like most other business enterprises, they require a certain amount of capital and lapse of time to render them productive. They are not therefore a proper investment for farmers or settlers of small means, dependent on annual crops for their livelihood and unable to bring to bear upon these soils the proper means for their reclamation, unless, indeed, local conditions should enable them to use successfully some of the crops specially adapted to alkali lands.

CROPS SUITABLE FOR ALKALI LANDS.

As has already been stated, the search for generally available crops that will thrive in strong, unreclaimed alkali land has not thus far been very successful. Of the native vegetation found on it within the United States, none is thus far known that would be available to any considerable extent for stock feeding. Cattle will nibble alkali grass (*Distichlis maritima*), but will soon leave it for any dry feed that is within reach. When they are forced to eat such plants, looseness of the bowels and other disorders usually result, which in such ranges is, however, often counteracted to some extent by an aromatic antidote, such as the gray sagebrush, that. while not thriving in alkali lands, is fairly tolerant of the salts.

Late experiences in California seem to indicate that in at least the more southerly portion of the arid region the unpalatable native plants may be generally replaced, even on the ranges, by one or more species of the Australian saltbushes (*Atriplex* spp.) long ago recommended by Baron von Mueller, of Melbourne, of which at least one (*A. semibaccatum*) has proved eminently adapted to the climate and soil of California and is readily eaten by all kinds of stock. The facility with which it is propagated, its quick development, and the large amount of feed yielded on a given area, even in the strongest of alkali lands thus far tried, seem to commend it specially to the

farmer's consideration wherever the climate will permit of its use.[1] Its resistance to severe cold weather has not yet been tested. It is probable that other species, now also under trial, will equally justify the recommendation given them by the eminent botanist who first brought them into public notice as promising forage plants. It is to be noted that since the saltbushes take up nearly one-fifth of their dry weight of ash ingredients,[2] largely common salt, the complete removal from the land of a 5-ton crop of saltbush hay will take away nearly a ton of the alkali salts per acre. This will in the course of some years be quite sufficient to reduce materially the saline contents of the land, and render possible the culture of ordinary crops.

As regards the familiar culture plants, both the natural growth of alkali lands and experimental tests seem to show that the entire leguminous family (peas, beans, clovers, etc.) are among the more sensitive and least available wherever black alkali exists, while fairly tolerant of the white (neutral) salts. Apparently a very little salsoda suffices to destroy the tubercle-forming organisms that are so important a medium of nitrogen nutrition in these plants. Alfalfa, with its hard, stout, and long taproot, seems to resist best of all these plants. As a general thing, taprooted plants, when once established, resist best, for the obvious reason that their main mass of feeding roots reaches below the danger level. Another favoring condition, already alluded to, is heavy foliage and consequent shading of the ground; alfalfa happens to combine both of these advantages.

Several of the hardiest of the native "alkali weeds" belong to the sunflower family, and the common wild sunflowers (*Helianthus californicus* and *H. annuus*) are common on lands pretty strongly alkaline. Correspondingly, the "Jerusalem artichoke," itself a sunflower, is among the available crops on moderately strong alkali soils; and so, doubtless, are other members of the same relationship not yet tested, such as the true artichoke, salsify, chicory, etc.

The common beet (including the mangel-wurzel) is known to succeed well on saline seashore lands, and it maintains its reputation on alkali lands also. Being specially tolerant of common salt, it may be grown where other crops fail on this account, but the roots so grown are strongly charged with salt, and have, as is well known, been used for the purpose of removing excess of the same from marsh lands.

It is quite otherwise with Glauber salt (sodium sulphate); and as this is usually predominant in alkali lands, either before or after the

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[1] See Bulletin No. 105 of the California Experiment Station.

[2] Analyses made at the California station show 20.84 per cent of ash in the dry matter of Australian saltbush, 19.37 per cent in the air-dry material. (See California Sta. Bul. 105; E. S. R., vol. 6, p. 718.) Recent analyses of Russian thistle have been reported showing over 20 per cent of ash in dry matter. (See Minnesota Sta. Bul. 34; Iowa Sta. Bul. 26; E. S. R., vol. 6, pp. 552, 553.)

gypsum treatment, this fact is of great importance, for it permits of the successful growing of the sugar beet, as has been abundantly proved at the Chino ranch in southern California, where land containing as much as one-fourth of 1 per cent of salts, mostly this compound, has yielded roots of very high grade both as to sugar percentage and purity.

Asparagus is another crop which bears considerable amounts of common salt as well as of Glauber salt, but not of salsoda, which must first be transformed by the use of gypsum.

The superficial rooting and fine fibrous roots of the true grasses render them, as a whole, rather sensitive to alkali salts; yet there are a number of the perennial kinds whose thick roots and deeper rooting render them measurably resistant. Aside from the alkali grass proper (*Distichlis*), the so-called rye grass of the Northwest (*Elymus condensatus*) is probably the most resistant species among the wild grasses. Its southern form, with several others not positively identified, occupy largely the milder alkali lands of southern California, such as the low lands near Chino, already referred to as producing choice sugar beets.

While maize is rather sensitive, and fails on even slightly alkaline lands, Egyptian corn and other sorghums, rooting somewhat deeper, succeed on mild alkali soils of the white class. The same appears to be true of some of the stout-rooted millets, such as barnyard grass (*Panicum crus-galli*), of which the variety *muticum* (?) is reported to succeed well in neutral alkali land.

Of the important group of legumes (peas, beans, vetches, clovers, etc.), alfalfa appears thus far to be the most available, on account of its hardy, long, and deep-feeding taproots. Very few plants belonging to this family are naturally found on alkali lands, and attempts to grow them, even where only Glauber salt is present, have been but very moderately successful. The salts seem to retard or even prevent the formation of the tubercles useful for nitrogen absorption.

Of trees suitable for alkali lands, two native ones call for mention. One is the California white oak (*Quercus lobata*), which forms a dense forest of large trees on the delta lands of the Kaweah River in California, and is found scatteringly all over the San Joaquin Valley of California. Unfortunately, this tree does not supply timber valuable for aught but firewood or fence posts, being quite brittle. The native cottonwoods, while somewhat retarded and dwarfed in their growth in strong alkali, are quite tolerant of the white salts, especially of Glauber salt.

Of other trees, the oriental plane or sycamore and the black locust have proved the most resistant in the alkali lands of the San Joaquin Valley. Of the eucalyptus, the narrow-leafed *Eucalyptus amygdalina* seems to be least sensitive, and in some cases has grown as rapidly as anywhere. Next to these, the elms have done fairly well, as has also the large-leafed maple (*Acer grandidentatum*). The English.

oak (*Quercus pedunculata*) becomes stunted, as does the tulip tree (*Liriodendron*), the linden, and most other Eastern species of trees.

Of orchard trees, strangely enough, the shallow-rooted almond seems to resist best; peach is more sensitive; apricot does fairly; apples are very sensitive; pears somewhat less so; the olive resists very well; the fig is rather sensitive; the English walnut resents even a slight taint of black salts; the citrus fruits, while not very sensitive, are much retarded in their growth by any considerable amount of alkali in the soil.

The grapevine (*Vitis vinifera*) is quite tolerant of white or neutral alkali salts, and will resist even a moderate amount of the black so long as no hardpan is allowed to form. Vines rapidly succumb, however, when by excessive irrigation the bottom water is allowed to rise, killing the ends of the roots, shallowing the soil at their disposal and increasing the ascent of the alkali salts. In such cases sometimes the formation of hardpan is followed by that of a concentrated alkaline solution above it strong enough to corrode the roots themselves, and not only killing the vines, but rendering the land unfit for any agricultural use whatsoever. The swamping of alkali lands, whether of the white or black kind, is fatal not only to their present productiveness, but, on account of the strong chemical action thus induced, greatly jeopardizes their future usefulness. Many costly investments in orchards and vineyards have thus been rendered unproductive, or have even become a total loss.

While it is certainly true that when rightly treated alkali lands can be rendered profusely and lastingly productive, yet close attention and constant vigilance are needed so long as the salts remain in the soil; and no one not determined to give such land such full attention should undertake to cultivate it.

REASONS FOR CULTIVATING THE SOIL.

By MILTON WHITNEY,
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HOW WATER ENTERS THE SOIL.

Water is the most abundant substance found in living crops. Not only does it form by far the largest proportion of all fresh vegetable substance, but, on account of loss through evaporation from the leaves of growing plants and the necessity of replacing this loss, thirty or forty times more water is needed during the growing period of a crop than is contained in the crop when harvested. Plants require a large amount of water for their life and growth, and it is necessary that the supply should be abundant at all times. If the evaporation from the plant greatly exceeds the amount taken in through the roots, the leaves wilt and the plant suffers.[1]

Therefore one of the most important functions of the soil in its relation to crop production is the maintenance of a proper supply of water. Rain falls, on an average, in the humid portion of the United States for two or three days in succession, and is then followed by an interval of eight or ten days of fair weather. As plants are fixed in their relative positions in the earth, the soil, in order to supply them with water during the fair-weather period, has to offer such a resistance to the percolation of the rain that an adequate supply shall be held back. On account of this resistance, due to the friction which the rain encounters in the minute spaces between the soil grains through which it has to pass, the movement is very slow and only part of the water sinks below the reach of plants before the next rainfall occurs.

The resistance which soils, owing to their difference in texture, offer to the percolation of the rain varies greatly. Light, sandy soils maintain comparatively little moisture, because the spaces between the grains are comparatively large and there is relatively but little resistance to the flow of water, so that the rainfall moves down quite rapidly until there is only 5 or 10 per cent of moisture present in the soil. Strong clay soils, on the other hand, have very minute spaces for the water to move through, and consequently offer a very great

[1] This subject was treated quite fully in an article by Galloway and Woods on "Water as a factor in the growth of plants," in the Yearbook for 1894.

resistance to the percolation of the rain. These soils maintain, as a rule, from 15 to 20 per cent of their weight of water.

Different plants grow best with different amounts of water. For instance, the pasture grasses thrive on a soil which is too moist for Indian corn, or even for the largest and surest yield of wheat. Some classes of tobacco thrive well on soils which are very retentive of moisture, while other classes can only be grown with success on drier soils. We are not concerned in this article with the amount of moisture which different soils maintain or with the amount of moisture required by different kinds of plants. We must recognize, however, that it is not possible nor desirable to maintain the same amount of water in all soils, for if this were done there would not be the opportunity for diversity in agriculture which we have under existing conditions.

While water is maintained for a time in the soil, as already explained, it is liable to be lost to the growing crop by evaporation from the surface of the ground or by being used up by weeds. The end sought in plowing and cultivation is to control the water supply by removing weeds and leaving the surface of the soil covered with a loose, dry mulch to retard evaporation. Many of our crops require no subsequent cultivation after they are put into the ground. Wheat, oats, rye, clover, grass, forest trees, and, in general, such crops as cover and shade the ground are not, as a rule, cultivated during their period of growth. On the other hand, such crops as corn, tobacco, cotton, potatoes, and fruit trees require cultivation during their early growing period, although even with these crops cultivation ceases after they have attained considerable size, and is rarely practiced during the ripening period.

The principal object of plowing is to loosen up the soil, for four purposes: (1) To enable the soil to absorb the rainfall more quickly and more freely than it would in its undisturbed condition; (2) to maintain more of the rainfall near the roots of plants; (3) to admit fresh air to the roots of plants; (4) to enable the roots of the young or quickly growing plants to penetrate the soil more easily.

The principal objects of subsequent cultivation, whether with plow, cultivator, cotton sweep, harrow, hoe, or rake, are (1) to prevent loss of water by weeds and grass, which use up great quantities; (2) to keep the surface covered with a loose, dry mulch in order to prevent, so far as possible, loss of water by evaporation. Water is thus conserved for the use of crops, and the supply is more abundant and more uniform than it would have been without the cultivation.

A soil with a compact surface quickly dries out, and the water supply fluctuates rapidly and excessively, to the detriment of most crops during their growing period. Weeds and grass are generally to be excluded from the crop because they transpire great quantities of water which would otherwise have been at the disposal of the crop. Weeds are, however, occasionally of advantage to the crop, especially during the ripening period, because they help to dry out the soil and thus hasten the maturity of the crop.

Some of our crops, therefore, do not require cultivation, because they shade the ground and prevent evaporation and prevent grass and weeds from springing up and diminishing their supply of water, or because they are deeply rooted and can bring water up from considerable depths. Other crops can not protect their water supply in this way, and it must be artificially controlled by methods of cultivation.

In tropical countries where rain falls nearly every day, giving an abundant and uniform supply of moisture in the soil, crops require little or no cultivation, and only the larger weeds need be removed from the field. The rainfall is sufficient, both in amount and distribution, for the support of the weeds and an average crop.

PRINCIPLES OF PLOWING.

The common plow is essentially a wedge-shaped instrument, which is forced through the soil to loosen it. The topsoil is forced aside, thrown up, and usually turned over. This action loosens the soil by separating the soil grains. The loose soil occupies more space than the compact soil did, and a cubic foot of the former, therefore, contains more space for water to enter. Each separate space, however, is also larger and has less capillary action and a smaller power of drawing water to the surface. If the soil, by reason of its fine texture or wet condition, is lumpy after the plowing, the spaces in the soil will be of very uneven size, and it frequently happens that the surface of the ground is not left in a suitable condition to draw water up from below. If small seeds are sown on such a rough surface, they are liable to suffer for lack of moisture. It is customary, therefore, and very advisable in such cases, to harrow and roll the seed bed until all the larger lumps are broken down and the surface is left smooth and even, in order to insure a supply of moisture to the seed during the germinating period. However, soil which has thus been rolled will lose more water by evaporation than soil which has been simply harrowed. The evaporation of this moisture is an incident which it is not always possible or desirable to prevent. With some crops the surface may be harrowed after the seed has germinated. This is desirable when it can be done without injury to the crop, as it tends to retard evaporation.

There is one serious defect in the principle of the common plow which, upon some soils and with certain kinds of plowing, is liable to have very serious effects. If a field is plowed for many successive years to a depth of 6 or 8 inches the tendency each time is to compact the subsoil immediately below the plow, thus rendering it more impervious to water; that is, the plow in being dragged along plasters the subsoil just as a mason with his trowel would smooth out a layer of cement to make it as close and impervious to water as possible. This is undoubtedly an advantage to some soils, but, on the other hand, it is very injurious to many.

The injurious effect of this compact layer formed by the plowing is twofold. It makes it more difficult for the rainfall to be absorbed as

rapidly as it falls, and increases the danger of loss of water and injury to the soil by surface washing. Soils plowed at a depth of 3 or 4 inches, which is quite common in many parts of the country, would have a thin layer of loose material on the surface, with a compact subsoil below, into which water would descend rather slowly. With a rapid and excessive fall of rain, the light, loose topsoil is liable to be washed away by the excess of water, which can not descend into the subsoil as rapidly as it falls. This washing of the surface and erosion of fields into gullies occasion the abandonment of thousands of acres of land. The field will not wash so badly if it is not plowed, and, on the other hand, it will hardly wash at all if the cultivation is deeper and the subsoil left in a loose and absorbent condition. The deeper the cultivation, the greater the proportion of rainfall stored away and the less danger of the erosion of the surface soil and the less serious the defect of our common method of plowing. While there is less danger from washing, however, with deep cultivation, there is still a tendency toward the formation of a hardpan at whatever depth the land is plowed. No simple modification of the ordinary plow or of the subsoil plow will overcome this defect. It will require a change in the very principle of the implement. The plow should not cut through the soil, but break it apart so as neither to compact nor puddle it by being dragged along over the subsoil.

While all other farm implements and machinery have been improved, especially within the last fifty years, so that we are able now to harvest more crops than ever before and to handle our crops to better advantage, our common plow has not been essentially improved or modified in any important particular, except as to mechanical construction, since the days of the early Greeks and Romans. It would seem only necessary to call attention to this, the fundamental and simplest principle of agriculture, to have some new method devised of stirring the soil without compacting the subsoil.

The highest art of cultivation which has ever been practiced is that of trenching, so extensively employed in England and so earnestly advocated by the early English writers on agriculture. With a large class of lands there is no implement so effective for loosening and improving the soil conditions as the spade. The spade does not cut the soil from the subsoil as the plow does, but breaks it off, and there is little or no disturbance and no compacting whatever below that point. Everyone is familiar with the difference in the tilth of a garden which has been thoroughly spaded and of a field plowed in the ordinary way. This old method of trenching with a spade can not, of course, be used in the extensive systems of cultivation practiced in this country, and it is now used in England much less than it was years ago, but if this principle could be worked into a practical method of cultivation it would be of great benefit to agriculture.

PRINCIPLES OF SUBSOILING.

At the present time little is known definitely about the practical value of subsoiling. In certain localities it has or has not been found to be beneficial to crops. There is a wide difference of opinion upon this fundamental point. Fifteen or twenty years ago it was very generally advocated throughout the East by all of the agricultural journals. It was tried in a great variety of soils and under many conditions, and there is no doubt that in perhaps a majority of cases it showed no beneficial effects. This might have been expected, for no one method of cultivation can be equally valuable under the various conditions of soils, climate, and crops such as prevail over such a great extent of country. At present the subject is being prominently agitated in some of the Western States, particularly in the semiarid regions, and very favorable results are being reported through the local agricultural papers.

A few general principles only may be laid down for guidance in this matter. Subsoiling is rarely necessary in light, porous, sandy soils or in a climate where there are frequent light showers. It is not beneficial in heavy, wet soils, unless they are previously thoroughly underdrained. It is likely to be injurious if in the operation much of the subsoil is brought to the surface and incorporated in the surface soil, especially if the subsoil itself is in an unhealthy condition as regards drainage and contains poisonous matters which would be deleterious to plant growth. Poisonous matters frequently occur in subsoils as a result of improper aeration and the growth of certain minute organisms.

Subsoiling when properly done consists merely of breaking up the subsoil without bringing it to the surface or in any way incorporating it with the upper layer of the soil. In this respect it differs from deep plowing. The ideal subsoil plow consists merely of a tongue fashioned much like a common pick and hardly larger in its dimensions—slightly smaller at the point than in the rear, but as small in all its parts as is consistent with perfect rigidity and with the nature of the soil through which it is to be drawn. This usually follows an ordinary plow. It should be run at as great a depth as possible, the endeavor being to get it at least 16 or 18 inches below the surface. It is often advisable by this means to break up a hardpan formed, perhaps, by long-continued plowing at a uniform depth or existing as a natural formation below the surface.

Subsoiling is likely to be beneficial, under the prevailing climatic conditions east of the Mississippi River, in any soils of medium or of heavy texture, provided the land has fairly good drainage. In the semiarid region of the West it is likely to be very beneficial upon many classes of soils, especially where the rainfall occurs in heavy and infrequent showers and where it is necessary to increase the capacity of the soils to absorb water readily and rapidly.

loam or even in light sandy soils. It is practiced to a considerable extent in the light sandy soil of the truck area of the Atlantic Seaboard, where the question of a few days in the time of ripening of the crop is an important factor.

IRRIGATION.

If the climatic conditions are such that it is impossible, with the most improved methods of plowing, subsoiling, and subsequent cultivation, to maintain a sufficient amount of moisture in the soil for the use of crops, it is then necessary to resort to irrigation or the artificial application of water to the soil. It is not the purpose here to enter into a discussion of the best methods of irrigation, but simply to discuss briefly the general principles of irrigation as practiced in maintaining proper conditions in the soil.

Our ideas of irrigation should not be confined to the arid regions. To be sure, irrigation is much more important there than elsewhere, for without artificial application of water crops could not be produced in many localities. In the humid portion of the United States, even in localities in Florida where they have from 60 to 70 inches of annual rainfall, irrigation is used successfully as a means of insuring the crop against drought due to the uneven distribution of the rainfall. It has been pointed out in several publications of this division that where the supply of water in different soils reaches a certain point, which differs according to the texture of the soil, crops suffer for lack of it. In the truck soils of the Atlantic Coast this minimum is approximately 4 per cent, while in the heavy limestone grass lands of Kentucky the pasture begins to dry up when the soils contain as much as 15 per cent of water.

Under our present modes of cultivation the farmer can do little for the crop during the time of actual drought. Ordinary cultivation is of comparatively little benefit during a prolonged dry season. Its most effective work is before the dry spell sets in. No matter what the value of the crop, and no matter how much this value is concentrated on small areas of land, there is practically but little to be done to save the crop. Irrigation should be used as an insurance against the loss of crops. A small pond fed by a windmill would often save a garden or a small area of a valuable crop from destruction or great injury during a dry season. A small portable farm engine, which would be available at other times for cutting feed, thrashing grain, and other farm purposes, could be used to drive an irrigating pump during the dry seasons. This would be particularly valuable for tobacco, truck, and other crops which are grown under a very intensive system of cultivation.

The object of all cultivation, in its broadest aspect, is to maintain, under existing climatic conditions, a uniform and adequate supply of water and air in soils adapted to different classes of plants. This is the object alike of plowing, subsoiling, cultivation, underdrainage, and irrigation; they are all processes to be used in maintaining suitable moisture conditions for the growth of crops.

HUMUS IN ITS RELATION TO SOIL FERTILITY.

By Harry Snyder, B. Sc.,
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The term humus is applied to a large class of compounds derived from the decay of former animal and plant life. The animal and vegetable materials (organic matter) undergo decomposition in the soil, the final result of which is the disappearance of these substances, leaving only a few gases and a small amount of mineral matter. When the organic matter is in its intermediate stages of decomposition, and mixed with the soil, it is known as humus.

Opinion as to the fertilizing value of humus has swung, pendulum like, from one extreme to another. The alchemists taught that the spirits left the decaying animal and vegetable matters and entered plants. By many of the earlier chemists, humus was considered as supplying the larger part of the materials necessary for the development of the crop, but when the combined labors of De Saussure, Boussingault, Dumas, and Liebig demonstrated that the air supplied plants most of their food, particularly that part which was supposed to come from humus, scientists, as a rule, assigned a low value to humus.

From the very earliest times, however, farmers have assigned a very high value to humus as a factor of soil fertility, and this belief was strengthened by the observed facts that soils rich in humus were, as a rule, highly productive, and that such materials as animal excrement or barnyard manure, which supplied the soil with an abundance of humus, possessed a marked fertilizing power. Although many of the old theories which were supposed to account for the value of humus are no longer tenable, recent experiments have shown that there are sound scientific reasons for ascribing to humus a high value as a factor of soil fertility, and have demonstrated that "farmers are wholly right in attaching great importance to the preservation of humus in their soils."

As the following pages will show, humus performs a number of different functions in the soil which are of the highest importance in crop production. It influences the temperature, tilth, permeability, absorptive power, weight, and color of soils, and directly or indirectly controls to a high degree their supply of water, nitrogen, phosphoric acid, and potash.

LOSS OF SOIL HUMUS AND DECLINE IN FERTILITY.

A virgin soil or one recently cleared may show a high state of productiveness for a number of years after it is brought under cultivation. Gradually, however, a decline in fertility is observed, which is slight at first, but more marked after a lapse of fifteen or twenty years.

Experiments have shown that the decline in fertility is not entirely a result of the removal from the soil of the essential fertilizing elements—nitrogen, phosphoric acid, potash, or lime—but is due in many cases to getting the land out of condition through a loss of humus. Experiments conducted by the Minnesota Agricultural Experiment Station on different types of soils worn by continuous grain cropping have shown that when a fertilizer was used containing nitrogen, phosphoric acid, potash, or lime, or when any one of these materials was applied alone, there was "in no case an increase of over 3 bushels per acre of wheat and 2 of flax. * * * With soils that have been cropped for twenty years, the largest increase was 4 bushels per acre." The difference between the grain-producing power of new soils and of worn soils of the same original character was about 15 bushels per acre. These results, as well as many others which could be quoted, make it clear that the decline in fertility of the soils was not entirely due to a loss of the essential elements of fertility, and that we must seek the cause elsewhere.

The most important difference, physical or chemical, between the composition of old, worn soils and new soils of the same character is in the amount of humus which is present.

That the loss of humus is an important factor in the decline of fertility is also indicated by the fact that with methods of farming in which grasses form an important part in the rotation, especially those that leave a large residue of roots and culms, the decline in productive power is much slower than when crops like wheat, cotton, or potatoes, which leave little residue on the soil, are grown continuously. Under grass and similar crops the soil humus increases from year to year, while the continuous culture of grain, cotton, or potatoes gradually reduces the original stock of humus. Grass and grain crops in rotation result in alternately increasing and decreasing the humus of the soil and keep the land in a higher state of productiveness, although more nitrogen, phosphoric acid, and potash is removed from the soil than when grain, cotton, or corn is raised continuously. In no case, however, do those systems of farming which return humus-forming materials to the soil reduce the land to so low a state of productiveness as do those systems in which there is a continual loss of humus from the soil (see p. 141).

Agriculturally considered, the two most important points regarding the composition of humus are (1) the presence of nitrogen as a

constant constituent, and (2) the chemical union of the humus with potash, lime, and phosphoric acid, forming humates.

NITROGEN IN HUMUS.

Humus, as ordinarily obtained from the soil, contains from 3 to 12 per cent of nitrogen. According to Professor Hilgard, the soils from arid regions are poor in humus, containing from 1 to 2 per cent, but this humus is correspondingly rich in nitrogen, in many cases containing 14 per cent. In many of the prairie regions the soil contains about 5 per cent of humus, and this humus contains about 10 per cent of nitrogen. Since, therefore, nitrogen is one of the prominent constituents of humus, it is easily understood how a loss of humus has also resulted in a loss of nitrogen. This decline in the nitrogen content of the soil is one of the most serious results of the loss of humus from the soil. A virgin soil containing 4 per cent of true humus and 0.35 per cent of nitrogen will after twenty years of grain cropping show about 2.5 per cent of humus and 0.2 per cent of nitrogen.

In the twenty years, therefore, there has been a loss of 1.5 per cent of humus, equivalent to about 3,500 pounds per acre, and 0.15 to 0.2 per cent of nitrogen, which is equivalent to 3,000 to 5,000 pounds of nitrogen per acre. Since 50 pounds per year of nitrogen is a large quantity for any ordinary grain crop to remove, the 20 crops have at the most removed 900 pounds of nitrogen. At least 2,500 pounds have, therefore, been lost by the decomposition of the humus, the nitrogen being lost either in the free state or in the drainage waters. For every pound of nitrogen removed in the crops during the twenty years of cultivation there has been an additional loss of 3 or 4 pounds of nitrogen from the soil by the decomposition of the humus.

We know that most if not all of the changes that organic matter undergoes are the result of the action of microscopic organisms. Such changes as nitrification, or the transformation of organic nitrogen into nitrates and its opposite denitrification, or the reduction of nitrates to gaseous nitrogen, besides many others which might be mentioned, are illustrations of the work of these minute organisms. Humus furnishes a medium peculiarly adapted to the activity of these organisms. The decomposition of humus, by which it loses its nitrogen, is due chiefly to the combined action of the organisms of nitrification and denitrification. The nitrifying organism feeds upon the humus, breaking down its organic nitrogenous constituents and producing nitrates which may be washed out in the drainage, and the denitrifying organism completes the work by feeding upon the nitrates, producing free nitrogen gas, which escapes into the air.

Nitrification is one of the most important natural provisions for rendering the inert fertility of the soil available to plants, and a certain amount of it is necessary to plant growth, but it can be readily seen that under injudicious management or cultivation of the soil

it may work a positive injury by causing unnecessary waste of the nitrogen, or, in case of rich soils, it may supply the growing crop with too much nitrate and thus produce a rank growth of straw and leaves.

Summer fallowing.—Bare summer fallowing is widely practiced, and has been very beneficial to the succeeding crop by increasing the available nitrogen of the soil, but frequently more nitrogen is rendered available than is necessary for the following crop, and whatever the crop is unable to utilize is lost by leaching or else escapes into the air. The available nitrogen is thus increased, while the total nitrogen is greatly decreased.

Experiments at the Minnesota Agricultural Experiment Station indicated that one year of fallowing caused a gain of 0.0022 per cent available nitrogen and a loss of 0.0114 per cent of total nitrogen in a soil containing originally 0.1536 per cent of total nitrogen and 0.0002 per cent of available nitrogen. For every pound of nitrogen rendered available by the fallow treatment there was a loss of over 5 pounds of nitrogen from the soil. Bare summer fallowing is, therefore, only temporarily beneficial at the expense of the total humus and nitrogen of the soil. When a soil is poor in humus and nitrogen the loss of nitrogen is much smaller, but even then it is doubtful whether bare summer fallowing is a wise practice. In no case should summer fallowing be practiced on a new soil.

Fall plowing keeps the humus and nitrogen of the soil in better condition than late spring plowing. Nitrification goes on in the soil until quite late in the fall, and in the South the process goes on the entire year. The change is most rapid near the surface, where there is plenty of oxygen from the air. In early fall plowing the available nitrogen formed from the humus is near the surface, where it does the sprouting seeds and the young crops the most good. With late spring plowing this available nitrogen is plowed under, and inert organic nitrogen is brought to the surface.

In old soils the process of nitrification does not go on rapidly enough to furnish available nitrogen to the crop. In a new soil the process of nitrification is liable to go on too rapidly. Deep plowing and thorough cultivation aid in nitrification. Hence the longer the soil is cultivated, the deeper and more thorough must be its preparation. Plowing must be done at the right time, preferably in the fall, so as not to interfere with the next year's water supply.

The application of lime and wood ashes aids in the reduction of nitrogen of humus to available forms and prevents the formation of sour mold. Good drainage is also necessary to nitrification in the soil. In water-logged soils the humus does not decompose normally, but peat is produced on account of the absence of oxygen.

We thus see that nitrification, although sometimes a serious source of loss, may be largely controlled by careful management of the soil.

Burning over of soils.—Another source of loss of humus in the prairie and forest regions is the frequent burning over of the land. Soils covered with pine, in which sand largely predominates, frequently lose half or three-quarters their total nitrogen when visited by forest fires. The sand, being of an open and porous nature, aids in the more complete combustion of the humus. In the timbered regions of the Northwest the great forest fires of 1894 resulted in the average destruction of over 1,500 pounds of humus nitrogen per acre, to say nothing of the nitrogen lost in the burning of the timber. Analyses of soils, before and after the fire, made by the Minnesota Agricultural Experiment Station showed a loss in some cases of 2,500 pounds per acre of nitrogen, equivalent to a loss of 75 per cent of the total amount in the soil. The prairie fires have not been so destructive upon the humus as the forest fires, because the burning has been confined more to the surface. An average prairie fire, however, will remove more nitrogen from the soil than five ordinary crops of wheat.

MINERAL MATTER IN HUMUS.

Besides being a great reservoir of nitrogen, humus is an indirect *means of supplying the plants with other fertilizing constituents.* Humus as it occurs in the soil is combined with potash, lime, phosphoric acid, and other compounds which are essential as plant food. The decaying animal and vegetable matters form various organic acids, which combine with the potash, lime, iron, and alumina, as well as with other elements, and form a series of compounds known as humates, of which but little is definitely known.

By some, the potash, lime, and other mineral constituents of the humus are regarded as simply associated with the humus and not organically combined with it, but there are a number of facts which indicate that the union is chemical and not simply mechanical. The mineral matter combined with the humus is characteristically rich in phosphoric acid and potash, two compounds which are of great value agriculturally. The mineral matter combined with the humus from different soil types, however, is not always of the same nature, and the amount of plant food thus combined with humus has not been extensively investigated. In the case of rich prairie soils over 1,500 pounds of phosphoric acid and 1,000 pounds of potash per acre to the depth of 1 foot have been found to be in combination with the humus. In the case of soils poor in humus and worn by cropping, the amount may be reduced to 100 pounds per acre. The average of analyses of the mineral matter of the humus from samples of productive prairie soils yielding 25 per cent of humates showed 7.50 per cent of potash and 12.37 per cent of phosphoric acid. In these soils, which were well supplied with humus, 1,500 pounds of phosphoric acid per acre out of a total of 8,750 was combined with humus, and 1,000 pounds of potash out of a total of 12,250 pounds. According to Hilgard, the amount of

phosphoric acid usually found associated with humus varies from 0.1 to 0.5 of the total amount in the soil, indicating in many cases the amount of this element available to plants.

VALUE OF HUMATES AS PLANT FOOD.

The value of these various forms of humates as plant food has been the subject of extensive investigations and many of these experiments indicate that the humates, when acted upon by the proper microorganisms, are very valuable forms of plant food.

At the Minnesota Agricultural Experiment Station oats and rye have been successfully grown when the only forms of mineral food were humates of potash, lime, magnesia, iron, and humic phosphate and sulphate. Humate material obtained from rich prairie soil was mixed with pure sand, which contains practically no plant food, and gypsum was added to prevent the formation of sour humus. The mixture was watered with leachings from a fertile field, so as to introduce the organisms which usually carry on the work of humus decomposition.

Oats seeded in the soil thus prepared finally produced fertile seeds, the entire plants containing fifty times more potash than was in the seeds sown, and over sixty times more phosphoric acid. The only source from which the plant could obtain these substances was the humates added to the soil.

In experiments in which the soil leachings were omitted the oat plants made only feeble signs of growth, plainly showing that unless the potash, phosphoric acid, etc., combined with the humus is set free by the action of microorganisms the plant is unable to use them.

There are a number of facts in field practice which also indicate that plants are capable of feeding on humates. The roots of plants, particularly those of grains, will always be found clustering around any decaying vegetable matter that may happen to be present in the soil. When wheat or oats follow a corn crop the roots of the grain will be found in many cases to completely incase any decaying pieces of cornstalks that are present. The cornstalks are not rich in plant food, but they decay in the soil and combine with the soil potash, phosphates, etc., forming humates which the grain feeds upon.

Large piles of sawdust many feet in height and circumference are frequently left around sawmills, or the sawdust is used for filling in low places. The sawdust is very slow in decomposing, but in time it is covered with vegetation which must obtain most if not all of its mineral food in the form of humates.

MEANS OF INCREASING THE HUMATES OF THE SOIL.

Inasmuch as both experiments and observations in the field appear to strongly indicate that plants have the power of feeding upon humates, it becomes important to determine to what extent the

addition of animal and vegetable matters to the soil is capable of affecting the amount of available plant food.

Experiments conducted at the Minnesota Agricultural Experiment Station have an important bearing upon this question. To a box holding 100 pounds of loam soil 20 pounds of cow manure was added. The contents of the box were kept moist and well mixed. At the end of twelve months the amount of mineral matter combined with the humus was determined, and the amount found compared with that originally in the box. Another box containing an equal amount of the same soil to which no manure was added was treated in the same manner. In the first case the mineral matter originally present in the manure was deducted, as well as the amount which was only soluble in the solutions used in the analysis. The results were as follows:

Increase of humates in the soil due to applications of manure.

	Total humates in 100 pounds of original soil.	Total at the end of 12 months in manured box.	Gain of humates from soil through manure.	Total humates at the end of 12 months, no manure.	Loss when no manure was added.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Potash	7.25	9.14	1.89	6.92	0.33
Soda	7.84	10.11	2.27	7.50	.34
Iron	2.44	4.13	1.69	2.46	....
Magnesia	.35	.54	.19	.27	.08
Alumina	2.96	4.64	1.68	2.75	.21
Phosphoric acid	11.97	13.99	2.02	11.50	.47

As will be seen, the cow manure increased the amount of mineral matter combined with the humus to the extent of 15 to 25 per cent of the original amount present in the soil. In addition to adding new elements of fertility to the soil, it has also resulted in changing a part of the potash, magnesia, and phosphoric acid, as well as other solid elements, into forms more valuable as plant food. The manure, therefore, not only has a direct fertilizing value, but is also useful in making the inert plant food of the soil more available. A number of facts in field practice also point to the same conclusion.

It is well known that barnyard manure is among the most lasting in effect of any of the fertilizers which can be applied. This is undoubtedly due to the power which the manure possesses of uniting with the soil potash, phosphoric acid, etc., to produce humates.

It has been frequently observed that when potatoes are cultivated on new prairie land for three or four years in succession, both the yield and the size of the potatoes decrease. When the land is seeded to a grass crop, the sod plowed under, and potatoes again planted, the yield and size of the potatoes are often nearly the same as when the land was new. This result has been attained without the addition of any manure to the land except the vegetable matter in the sod which has furnished materials for the formation of humates. In the same

way, wheat grown continuously on prairie soil will gradually decline in yield, but if grass is alternated with the wheat, nearly the original yields are restored.

Besides performing the useful functions just discussed, which are essentially chemical in character, humus profoundly modifies the physical properties of soils. This influence is most marked in relation to the water content and temperature of the soil.

HUMUS AND THE WATER SUPPLY OF CROPS.

A soil rich in humus not only absorbs more water, but holds it more tenaciously in time of drought than a soil poor in humus. In fact, this is one of the most important differences between soils rich in humus and those poor in humus. A soil which by long cultivation has lost half of its total humus will show a loss of 10 to 25 per cent of its water-holding power. These differences are well illustrated in the following table, compiled from data obtained in the examination of two typical Minnesota soils:

Water capacity of soils containing different amounts of humus.

	Water.		
	In original soil.	After 10 hours' exposure to the sun.	Loss.
	Per cent.	*Per cent.*	*Per cent.*
Soil richer in humus (3.75 per cent)	16.48	6.12	10.36
Soil poorer in humus (2.50 per cent)	12.14	3.94	8.20

Humus is also an important factor, especially in sandy soils, in assisting the capillary rise of subsoil water to the roots of crops. In a mixture of sand and humus, water will rise to the surface by capillarity much more rapidly than in pure sand. As is well known, soils which are properly manured and thus supplied with abundant humus retain more water and yield it up more slowly and evenly to growing crops than unmanured soils. The part which the humus takes in the water supply of crops is sufficient in itself for placing a high value upon the humus of the soil.

HUMUS AND THE HEAT OF THE SOIL.

Humus soils are generally considered cold or sour, but this is not always true of them. In humus soils decomposition or oxidation of the organic materials is constantly taking place, and this oxidation is accompanied by the evolution of a certain amount of heat. A portion of this heat is used up in warming and evaporating the additional water stored up in the soil on account of the humus, but even after this is provided for there is still some heat left from the oxidation of the humus to aid in warming up the soil.

It should be observed also that humus, as a rule, imparts a darker color to the soil, and thus causes it to absorb more of the heat of the sun. In autumn humus soils are not affected by sudden changes of temperature to the same extent as soils poor in humus, the difference frequently being sufficient to ward off an early frost and to enable corn in the Northern States to reach its full maturity.

Applications of humus-forming materials, such as manure, have frequently been observed to raise the temperature nearly a degree, and this in colder climates is often sufficient to prevent the growth of a crop from being checked. In the colder regions soils which are poor in humus freeze much deeper than soils which are richer in humus.

In the preceding pages the attempt has been made to demonstrate that the chemical action of humus in providing available plant food in the soil makes it of the greatest value as a fertilizer; that it assists materially in bringing about the physical conditions in the soil best suited to the growth of plants; that it furnishes a medium peculiarly suited to the activities of such organisms as those of nitrification, which are useful in plant growth; and that loss of humus from the soil is always attended by a marked decline in its productiveness. It is now important to discuss the means by which this valuable constituent of soils may be conserved and increased.

MEANS OF MAINTAINING THE HUMUS OF THE SOIL.

On account of the variable composition of humus it is difficult to state the definite amount which should be present in all soils. A large amount of humus, containing a very high per cent of carbon, approaching in many cases the composition of charcoal, is not as valuable as a smaller amount of humus which is capable of readily undergoing decomposition.

With an excessive amount of water, and in the absence or scarcity of the proper soil elements, like lime, potash, etc., humus-forming materials may produce sour soils, but in good soils well stocked with lime there is but little danger of this result. It is safe to conclude, therefore, that soils as a rule will be benefited by those systems of culture which conserve or increase the humus content.

The liberal use of well-prepared farm manures, green manuring, and a judicious rotation of crops are the three most important means of maintaining the humus of the soil. The preparation and use of farm manures and green manuring have already been discussed in some detail in bulletins from the U. S. Department of Agriculture,[1] and it is only necessary to briefly refer to these subjects here.

In the arid regions, and in many of the prairie sections, the proper preparation of *farm manures* is a problem which has not as yet been satisfactorily solved. On account of the slowness of decomposition

[1] Farmers' Bulletins Nos. 16 and 21.

of the straw in the manure, many farmers in the regions named have begun to look upon manure as a detriment rather than a benefit to the land. In these regions, however, the soil is in greater need of humus than in the regions of uniform summer rains, and it is of the highest importance to devise some system of preparing the manure produced on the farm so that it may be utilized to the fullest extent.

The humus materials of the soil may be increased by the use of well-prepared muck. It is best to draw the muck during the summer. After drying, it can be used as an absorbent in stables, for which purpose it is very valuable, many mucks having the power of absorbing more than their own weight of liquid. When muck is mixed with urine, it readily undergoes fermentation, which increases its fertilizing value. The brown mucks are much quicker in their action than the black. A little marl or land plaster mixed with the muck keeps it from forming sour mold.

Clover and plants of the leguminous family are more suitable for *green manuring* purposes than any other class of farm crops, because, in addition to supplying an abundance of humus-forming materials, they add to the soil large amounts of nitrogen drawn principally from the air. In the South the cowpea is extensively used for this purpose with good results, and crimson clover has proved valuable on the sandy coast soils of the Eastern States. Where land is cheap and fertilizers and labor are expensive, green manuring will doubtless prove to be the most economical way of maintaining fertility. Where land has a high value and labor is cheap, better returns will be obtained from feeding the crop to stock and using the manure rather than resorting to green manuring.

Rotation of crops.—Another means of maintaining the humus of the soil is the practice of proper systems of rotation of crops. The general laws which apply to the rotation of crops are in perfect accord with the conservation of the soil humus, but definite rules can not be given on account of the variations in soil and climate of different parts of the country.

The methods of farming which are the most destructive to the soil humus are continuous grain cropping without manures and the continuous cultivation of cotton, corn, or potatoes, while the methods which increase the soil humus are the growing of grass crops and dairy and stock farming, which result in the production of large quantities of manure. These statements are by no means intended to discourage grain, potato, or cotton growing, but they are intended to encourage a definite course of rotation in the culture of these crops, and the use of more well-prepared farm manures, so as to keep up the humus of the soil.

The influence of different systems of farming on the humus content and fertility of soils is illustrated by the four examples,

selected from a large number of similar import, given in the following table:

Influence of different systems of farming on the chemical and physicial properties of soils.

Character of soil.	Weight per cubic foot.	Humus.	Nitrogen.	Phosphoric acid combined with humus.	Water-holding capacity.
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1. Cultivated 35 years; rotation of crops and manure; high state of productiveness	70	3.32	0.30	0.04	48
2. Originally same as 1; continuous grain cropping for 35 years; low state of productiveness	72	1.80	.16	.01	39
3. Cultivated 42 years; systematic rotation and manure; good state of productiveness	70	3.46	.26	.03	59
4. Originally same as 3; cultivated 35 years; no systematic rotation or manure; medium state of productiveness	67	2.45	.21	.03	57

Soils Nos. 1 and 2 are from two adjoining farms, and originally had practically the same crop-producing power. No. 1 has received regular and liberal dressings of manure, and has produced wheat, corn, oats, timothy, and clover in rotation. There has been no apparent decline in fertility. No. 2 has been under continuous grain cultivation and has never received any farm manure or other humus-forming materials. During the first few years heavy crops of wheat were raised, but during the past few years the yield has been very low, especially in dry seasons. The land has been reduced in wheat-producing power from 25 to 8 bushels per acre.

The main difference between the two soils at the present time is in the amount of humus and nitrogen and phosphoric acid.

Soils Nos. 3 and 4 are from the same farm. No. 3 has been cropped forty-two years, timothy and clover, wheat, oats, and corn having been raised in rotation. Every five years the land has received 10 tons of stable manure per acre. No. 4 has been cropped only thirty-five years, producing mainly wheat, oats, and corn, with an occasional crop of timothy. It has not been cropped continuously to one crop, neither has it been under a regular system of rotation. The soil which has been cropped forty-two years shows more humus and nitrogen than the one which has been cropped thirty-five years.

SUMMARY.

(1) The decline in the crop-producing power of many soils is due to a loss of the partially decomposed animal and vegetable matters known as humus.

(2) The humus of the soil is decreased by the continuous cultivation of grain, cotton, potatoes, or any crop with which the land is

kept constantly under the plow without the addition of any humus-forming materials.

(3) The loss of humus involves a loss of the nitrogen, which is one of the elements composing humus. The loss of nitrogen from the soil is not always due simply to the nitrogen removed by the crop, but is frequently caused by waste of the humus by improper methods and systems of cultivation.

(4) The humus of the soil is increased by the use of well-prepared farm manures, green manures, and by a systematic rotation of crops in which grasses, or preferably clover, form an important part.

(5) The loss of humus from the soil results in decreasing its power of storing up and properly supplying crops with water. Soils with a liberal amount of humus are capable of more effectually withstanding drought than similar soils with less humus. In arid regions the loss of humus from the soil is more serious than in the regions of continuous summer rains.

(6) In sandy soils the loss of humus is most severely felt. In poorly drained soils, where there is a deficiency of lime, potash, and other similar materials, the humus may form sour mold, but this can usually be corrected by a dressing of lime, marl, or wood ashes.

(7) Humus-forming materials, like the decaying animal and vegetable matters in farm manures, have the power of combining with the potash and phosphoric acid of the soil to form humates which are readily assimilated by plants when acted upon by the proper soil organism. These humates thus increase to a marked extent the available plant food of the soil.

(8) Farm manures and other humus-forming materials are not only valuable for the elements of fertility which they contain, but also for the power of making the inert material of the soil more available to plants.

(9) In soils where there is a good stock of reserve materials it is cheaper to cultivate fertility through the agency of humus than it is to purchase it in the form of commercial fertilizers.

FROSTS AND FREEZES AS AFFECTING CULTIVATED PLANTS.[1]

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The object of this paper is to bring together some of the more important facts relating to frosts and freezes as affecting the farmer, gardener, and fruit grower. While for the most part the injurious effects of frosts on plants will be considered, it must not be forgotten that there are other aspects of the case. Frosts may kill or injure plants, but they also check many diseases affecting the human family. Furthermore, they are of the utmost importance in disintegrating the soil and underlying rocks and putting into condition the materials necessary for plant growth. These questions, however, do not concern us here, hence we may pass to a consideration of the kinds of frosts and freezes and how they affect plants.

KINDS OF FROSTS AND FREEZES.

Frosts and freezes vary both as regards their effects on plants and their origin and distribution.

Light frosts.—These may occur on clear, still nights, when the general temperature of the air is above freezing. If the sky is clear all exposed objects will cool down by the radiation of heat from their surfaces, and the cooling may proceed so far that the adjacent air deposits some of its own moisture upon them. If the temperatures of the surfaces and the adjacent air are above freezing this deposit will be dew, but if the temperatures fall below freezing the deposit will be hoar frost or some other form of ice.

The loss of heat by radiation is ordinarily checked by natural processes, such as a breeze or high wind, the clouding over of the sky, the formation of fog, or the convection of heat brought from a neighboring pond or river or from the warm soil below. In general, therefore, there is a tendency toward lower temperatures and the formation of frost on every clear night, the drier the air the greater being this tendency.

[1] This paper was prepared under the direction of the Assistant Secretary from material furnished by the Division of Vegetable Physiology and Pathology, and Prof. Cleveland Abbe, of the U. S. Weather Bureau.

Light frosts may begin to form a short time before sunrise and may be immediately checked by the warmth of the sun's rays. Sometimes frost may begin to form earlier, say about midnight, but soon after be checked by the formation of haze, fog, or cloud, or by the starting up of the wind, and thus what would be a serious frost is converted into a light one.

Heavy frosts.—These occur when the air is very dry and large areas of clear sky prevail. Under such conditions frost may begin to form by midnight, and neither cloud, fog, nor wind will check its progress.

Local frosts.—There are always to be found some spots where plants are peculiarly liable to damage by frosts. Usually such spots are a little lower than the surrounding region, and thus the cold air is more liable to collect in them, for the reason that the rapid loss of heat from the higher places causes the air to contract and become heavier. The heavy air then flows down into the depressions, while the warm air, being lighter, moves out and up to the higher places. Frosts occur in these spots or pockets on still, clear nights, when they do not occur on the neighboring dry soils, warm exposures, or highlands. Often a whole township or river valley is subject to local frosts, while neighboring townships are far less liable to suffer.

General frosts.—Frequently the condition of the atmosphere favors the occurrence of frost everywhere over large sections of the country. On nights when such conditions prevail the freezing is, of course, most severe in places subject to local frosts, as in lowlands, and least severe, but still injurious, on hilltops. Even then, however, it has been noticed that on the slopes of certain mountains there are regions rarely or never visited by such frosts. These regions are apparently warmed by the flow downhill of the cooling air, so that there is for every hillside a certain zone of elevation within which frost is least liable to occur.

Freezes.—It is, of course, difficult to draw the line between a freeze and a frost. So far as we are at present concerned, however, a freeze differs from a frost merely in intensity. It may penetrate the ground and freeze through and through the roots, stem, branches, and other parts of the plant. This may take place and still there may be no actual hoar frost visible anywhere on the plant.

HOW PLANTS ARE AFFECTED.

The effects on plants of the different kinds of frosts and freezes are, of course, exceedingly variable. Not only do the different degrees of cold produce different effects on the same plant, but the same plant will often behave differently when subjected to the same degree of cold. It is well known that plants or parts of plants in active growth are much more easily killed by low temperatures than the same plant or part when in a dormant condition. Actively growing plants contain relatively large quantities of water, so that it may be put down

as a rule that the larger the proportion of water contained within the plants the more likely are they to be injured by cold. It is a matter of common observation that quite tender plants may be hardened so that they will stand a considerable freeze.

All the phenomena involved in the freezing of succulent and other plants depend on the condition of the protoplasm or living matter in the plant cell. If the temperature is sufficiently low to cause a chemical disorganization of the living substance, the part of the plant where this takes place dies. If, on the other hand, no actual disorganization of the cell contents occurs, the affected parts may recover. It is hardly necessary here to enter upon a discussion of the various phenomena. Suffice it to say that under the influence of cold the water in the cells escapes, and may be frozen either in the spaces between the cells or on the surface of the leaf, stem, or whatever the part may be. As the temperature rises this frozen water may again be taken up by the cells, and in such cases little or no injury results. If for any reason, however, the cells are not able to regain the water withdrawn by the cold, injury or even death may result. In many cases the rapidity with which the ice is thawed has a marked effect on the ability of the cells to regain their normal condition. If the thaw is gradual, the water is furnished no faster than the cells can absorb it, and equilibrium is therefore soon restored, the chemical processes which were checked during the freeze are resumed and the plant soon regains its normal condition. With a rapid thaw, however, the cells are not able to take up the water as fast as it is furnished, and as a result chemical decomposition sets in and death follows. Death in this case is essentially the same as that which results from drought. The cell loses water to such an extent that it is not again able to become turgid, and as a result it finally withers and dies.

It will be seen from the foregoing that it is not always safe to conclude that a succulent plant is killed because it is frozen. The contents of the cells, as has been shown, may have given up much of their water in the formation of ice and still be able to revive under proper conditions. These conditions, however, will be discussed more in detail in another part of this paper.

Speaking generally, it is the late spring and early autumn frosts which are the most damaging to the farmer, gardener, and fruit grower. These frosts are especially destructive where intensive cultivation is practiced, as, for example, among truck farmers, market gardeners, growers of peaches, grapes, and small fruits, tobacco raisers, and others. Early autumn frosts are frequently very destructive in the Eastern grape regions, coming on and destroying the grapes before they can be gathered.

The general frosts and freezes which prevail during winter are destructive to plants in many ways, only a few of which can be referred

to here. The separation of the bark from the wood in many of our trees, notably the apple, is one of the most serious troubles. In some parts of the West, particularly in Illinois, Missouri, and Nebraska, it is not an uncommon thing for hundreds of bearing trees to be killed by this trouble, which, to the best of our present knowledge, is due, either directly or indirectly, to freezing. By the formation of ice in the cambium layer, or active growing tissue between the wood and bark, the bark is forced away from the wood, the rupture probably taking place in the layer itself. Sometimes the bark is split, but usually this is not the case. The injured parts may not die immediately, and for this reason the damage may not become apparent for months i. e., toward the middle of summer, at which time the leaves appear sickly and an examination will show the injury to the trunk near the ground. Usually the trunk is most severely injured on the side toward the sun, and on this account the opinion generally prevails among fruit growers that the trouble is largely brought about by alternate freezing and thawing or by sudden thawing after a severe or prolonged freeze.

One of the common effects of freezing on the trunks of trees is the splitting of the bark and wood. This is usually due to the formation of ice in the heartwood, producing a high internal pressure. It rarely causes any particular damage to the tree, excepting its disfigurement.

It is a matter of common observation that a dry summer, followed by a wet autumn, leaves plants in poor condition to stand the winter. During the dry summer the plants remain in a partial resting condition, and when rains set in there is a renewed period of growth, which does not mature before winter and is therefore killed by the first hard freeze. Late summer plowing or the application of stimulating fertilizers toward the close of the season also frequently results in the formation of immature wood, which is killed during the winter. Undoubtedly also the defoliation of many of our fruit trees, notably the pear, by such fungous diseases as leaf blight, results in the formation of wood which is easily winterkilled.

HOW TO FORETELL FROSTS.

Use of the daily weather map.—The possibility of being able to determine in advance the approach of frosts likely to be destructive to growing crops is of the utmost importance to those engaged in more or less intensive lines of agriculture. The market gardener, the truck farmer, the fruit grower, and others engaged in similar lines of work often have the greatest interests at stake in the spring and fall, and there is no doubt that timely frost warnings are of the greatest value to them.

In making predictions of approaching frosts the most reliable information is to be obtained from a study of the daily weather map issued by the Weather Bureau. These maps, unfortunately, can not reach

all who are actually engaged in raising plants, and too often their value is not understood by those who really have access to them. For the latter reason it seems desirable to offer a few suggestions as to how the maps may be made useful, especially to those living near cities, where the maps can in all probability be obtained early each day. To make the matter clear, a specimen weather map is reproduced in the accompanying illustration (fig. 8).

At first sight this map presents merely a number of lines and figures, which, however, will be clear after a little explanation and study. The full black lines indicate the pressure of the atmosphere as shown by the barometer, while the broken lines indicate the temperature of the free air at the level of the highest housetops. Shaded portions show where rain or snow has fallen during the twelve hours preceding the issue of the map.

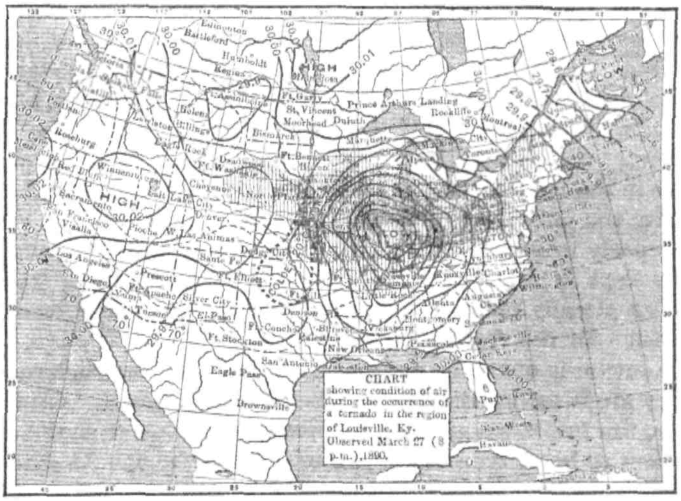

FIG. 8.—Specimen weather map.

In addition to the lines numerous dots, or symbols, are seen. Each of these has its special significance, which is as follows:

An arrow indicates the direction in which the wind is blowing; that is, it flies with the wind.

O A circle indicates a clear sky and calm weather at that place.

A dot with a black bar indicates a sky half clouded.

A cross-barred dot indicates that it is snowing.

A black dot with a white center indicates a wholly clouded sky.

A full black dot indicates that it is raining, and when combined with an arrow shows the direction of the wind.

It will be seen from the map that the series of black lines are arranged in approximate circles around two spots, one of which is

marked "low" and the other "high." These two words have reference to the state of the barometer. The areas of low pressure travel over the country generally from west to east, and as a rule each is followed by an area of high pressure, so that a continuous succession of low and high areas are passing over. The lows are commonly associated with rain or snow and a rising temperature, while the highs mark the advent of clear weather, with falling temperature, frosts, etc. Sometimes the lows and highs move from the southwest to the northeast, and sometimes they come from the northwest, turn to the east in the region of the Missouri River, and pass northeastward over the Great Lakes to the Gulf of St. Lawrence. In winter they often move from the northwest as far south as Louisiana, and then turn northeast. Sometimes areas of low pressure originate in the West Indies, move northwest, and turn northeast. These occur chiefly in August and September, constituting the West Indian hurricanes, and are usually accompanied by downpours of rain and by high winds.

The observations which form the basis of the weather maps are made twice daily, at 8 o'clock morning and evening, seventy-fifth meridian time, which is 7 o'clock by standard central time, at all the stations in different parts of the United States where the work is carried on. As soon as the observations are made they are telegraphed to the local forecasters and also to Washington, and are used in making the published forecasts and maps.

To properly interpret a map with reference to frosts, several points must be kept in mind. In the first place, the injurious frosts and freezes, as already pointed out, usually occur in connection with the high areas. In the front or advancing edge of a cold wave, the fall in temperature is apt to be great and sudden and is in such cases predicted by the Weather Bureau by the cold-wave signal. Oftentimes, however, the fall is too gradual to justify a cold-wave signal and yet is sufficient to bring on a dry freeze or a heavy frost. At other times the general air temperatures are too high to produce a general frost, but after the wind has gone down a light or local frost occurs.

There is not sufficient regularity in the movement of the high areas to justify a prediction several days in advance, but from the map of any morning it may safely be decided whether there is a probability of danger in any particular locality on the following morning. The sudden and severe changes in temperature are shown on the map by heavy dotted lines, marking the regions where the temperature has fallen twenty degrees or more in the preceding twenty-four hours. These, however, are the temperatures of the wind as it blows through the thermometer shelters used by the Weather Bureau, but as the shelters are located high above the ground it is necessary to remember that the temperatures of the surface of the ground in the open air at sunrise will be decidedly lower than those shown upon the map. As a rule, a minimum temperature of 40° F. in a Weather Bureau shelter

on a clear night means a temperature lower than 32°, or freezing, on the roofs of buildings in the city or at the surface of the ground in the adjacent country. There are, in fact, many cases in which frosts have been recorded when the adjacent Weather Bureau record was as high as 47°.

Summarizing briefly the facts in regard to the use of the map, it may be said that the lows and highs pass over the country westward to eastward, moving at the rate of about 500 miles a day. The lows are usually accompanied by relatively warm weather, rains, or snows, while the highs are accompanied by clear and cool or cold weather and high winds. With a knowledge of these facts it will be seen that the maps can be made to serve a very useful purpose, as the progress of approaching storms, good weather, cold waves, or frosts can be foreseen from day to day. The predictions of frost are verified in so many cases that those having large interests at stake should endeavor to obtain as early as possible the warnings sent out. Of course, in this connection local conditions must be considered. Light local rains preceding a cold wave may often be sufficient to protect the regions where the precipitation has occurred. The character of the soil, the shape of the land, proximity to forests, water, etc., will all have more or less influence. Those who grow plants are naturally close observers of local meteorological conditions, and with the knowledge of the peculiarities of the farm as regards liability to frost, aided by the published warnings, proper precautions can be taken.

Local observations on moisture of the air.—The air always contains moisture, but the amount varies greatly. As the temperature of the air rises its capacity for moisture increases, and consequently as it becomes colder its capacity for moisture becomes less. It is obvious, therefore, that if air containing a given amount of moisture is cooled to a certain point it will eventually become saturated or reach what is known as the dew-point. If the temperature at which dew is formed is above freezing, then the plants will be protected from further cooling; but if the air has so little moisture that it must be cooled to a temperature below freezing before dew is formed, then there is a probability that the plant will be injured by the low temperatures.

FIG. 9.—Sling psychrometer.

The determination of the dew-point may be made at sunset, or, preferably, a little later, and if it remains unchanged during the night it aids in determining whether frost is likely to occur. A number of instruments are used for determining the dew-point, one of the simplest and most inexpensive of which is known as the sling psychrometer. This consists of two thermometers fastened side by side on a metal back, as shown in fig. 9. One of the thermometers has a covering of very thin muslin slipped over the bulb containing the mercury. The other thermometer has no covering whatever. To use the instrument the thermometer having its bulb covered with muslin is dipped in a cup or wide-mouth bottle containing clean rain water or water as free from mineral matter as possible. After the muslin is thoroughly soaked with water, the instrument is whirled rapidly in the air for about a minute. This is done by means of the handle shown in the figure. The thermometers are then stopped and both are read as quickly as possible. A mental note of the two readings is made and the instrument is again whirled and again read as before. This is repeated three or four times, or until the reading of the bulb covered with wet muslin, or the wet bulb, as it is called, is found to remain nearly stationary. Ordinarily it will be found that there is a difference of several degrees between the reading of the wet and dry bulbs, as the former is cooled by the evaporation. This difference is known as the depression of the wet bulb, and increases in proportion to the dryness of the air in which the instrument is being whirled. When the air is saturated the wet and dry bulbs will agree very closely. From the readings obtained as described the dew-point may be determined by means of the tables given below:

TABLE 1.—*Temperature of the dew-point in degrees Fahrenheit.*

t Dry thermometer.	Difference between the dry and wet thermometers (*t*—*t'*).						*t* Dry thermometer.	*t* Dry thermometer.	Difference between the dry and wet thermometers (*t*—*t'*).						*t* Dry thermometer.
	1°	2°	3°	4°	5°	6°			1°	2°	3°	4°	5°	6°	
20	17	13	8	2	—6	—19	20	37	35	32	30	27	24	21	37
21	18	14	9	4	—4	—15	21	38	36	33	31	28	26	22	38
22	19	15	11	6	—1	—11	22	39	37	34	32	29	27	24	39
23	20	16	12	7	+1	— 8	23	40	38	35	33	30	28	25	40
24	21	18	14	9	3	— 5	24	41	39	36	34	32	29	26	41
25	22	19	15	11	5	— 2	25	42	40	38	35	33	30	27	42
26	23	20	16	12	7	0	26	43	41	39	36	34	31	29	43
27	24	21	18	14	9	+ 3	27	44	42	40	37	35	32	30	44
28	25	22	19	15	11	5	28	45	43	41	39	36	33	31	45
29	26	24	20	17	12	7	29	46	44	42	40	37	35	32	46
30	27	25	22	18	14	9	30	47	45	43	41	39	36	33	47
31	29	26	23	19	15	11	31	48	46	44	42	40	37	35	48
32	30	27	24	21	17	13	32	49	47	45	43	41	38	36	49
33	31	28	25	22	18	14	33	50	48	46	44	42	40	37	50
34	32	29	26	24	20	16	34	51	49	47	45	43	41	38	51
35	32	30	28	25	22	18	35	52	50	48	46	44	42	40	52
36	34	31	29	26	23	19	36	53	51	49	47	45	43	41	53

TABLE 1.—*Temperature of the dew-point in degrees Fahrenheit*—Continued.

t Dry thermometer.	Difference between the dry and wet thermometers ($t-t'$).						*t* Dry thermometer.	*t* Dry thermometer.	Difference between the dry and wet thermometers ($t-t'$).						*t* Dry thermometer.
	1°	2°	3°	4°	5°	6°			1°	2°	3°	4°	5°	6°	
54	52	50	49	46	44	42	54	68	67	65	63	62	60	58	68
55	53	52	50	48	46	43	55	69	68	66	64	63	61	59	69
56	54	53	51	49	47	44	56	70	69	67	66	64	62	61	70
57	55	54	52	50	48	46	57	71	70	68	67	65	63	62	71
58	56	55	53	51	49	47	58	72	71	69	68	66	64	63	72
59	57	56	54	52	50	48	59	73	72	70	69	67	66	64	73
60	58	57	55	53	51	49	60	74	73	71	70	68	67	65	74
61	59	58	56	54	52	50	61	75	74	72	71	69	68	66	75
62	60	59	57	55	53	52	62	76	75	73	72	70	69	67	76
63	61	60	58	56	55	53	63	77	76	74	73	71	70	68	77
64	62	61	59	57	56	54	64	78	77	75	74	72	71	69	78
65	63	02	60	59	57	55	65	79	78	76	75	73	72	70	79
66	64	63	61	60	58	56	66	80	79	77	76	74	73	72	80
67	66	64	62	61	59	57	67	*t*.	1°	2°	3°	4°	5°	6°	*t*.

TABLE 2.—*Temperature of the dew-point in degrees Fahrenheit.*

t Dry thermometer.	Difference between the dry and wet thermometers ($t-t'$).						*t* Dry thermometer.	*t* Dry thermometer.	Difference between the dry and wet thermometers ($t-t'$).						*t* Dry thermometer.
	6°	7°	8°	9°	10°	11°	12°			6°	7°	8°	9°	10°	11°	12°	
19	−25	.....	.....	.....	.....	.....	.....	19	51	38	36	33	31	28	24	21	51
20	−19	.....	.....	.....	.....	.....	.....	20	52	40	37	34	32	29	26	23	52
21	−15	−47	.....	.....	.....	.....	.....	21	53	41	38	36	33	30	28	24	53
22	−11	−31	.....	.....	.....	.....	.....	22	54	42	40	37	34	32	29	26	54
23	− 8	−24	.....	.....	.....	.....	.....	23	55	43	41	39	36	33	30	28	55
24	− 5	−18	.....	.....	.....	.....	.....	24	56	44	42	40	37	34	32	29	56
25	− 2	−13	−42	.....	.....	.....	.....	25	57	46	44	41	39	36	33	30	57
26	0	− 9	−28	.....	.....	.....	.....	26	58	47	45	42	40	37	35	32	58
27	+ 3	− 6	−20	.....	.....	.....	.....	27	59	48	46	44	41	39	36	33	59
28	5	− 3	−15	−54	.....	.....	.....	28	60	49	47	45	43	40	38	35	60
29	7	0	−10	−32	.....	.....	.....	29	61	50	48	46	44	42	39	36	61
30	9	+ 2	− 6	−22	.....	.....	.....	30	62	52	50	48	45	43	41	38	62
31	11	5	− 3	−15	.....	.....	.....	31	63	53	51	49	47	44	42	39	63
32	13	7	0	−10	−33	.....	.....	32	64	54	52	50	48	46	43	41	64
33	14	9	+ 3	− 6	−22	.....	.....	33	65	55	53	51	49	47	45	42	65
34	16	11	6	− 2	−15	.....	.....	34	66	56	54	52	50	48	46	44	66
35	18	13	8	+ 1	− 9	−32	.....	35	67	57	55	54	52	50	47	45	67
36	19	15	10	4	− 5	−20	.....	36	68	58	57	55	53	51	49	46	68
37	21	17	12	6	− 2	−14	−52	37	69	59	58	56	54	52	50	48	69
38	22	19	14	9	+ 2	− 8	−29	38	70	61	59	57	55	53	51	49	70
39	24	20	16	11	5	− 4	−18	39	71	62	60	58	56	55	53	51	71
40	25	22	18	13	8	0	−12	40	72	63	61	59	58	56	54	52	72
41	26	23	20	15	10	+ 4	− 6	41	73	64	62	61	59	57	55	53	73
42	27	24	21	18	12	7	− 2	42	74	65	63	62	60	58	56	54	74
43	29	26	23	19	14	9	+ 2	43	75	66	64	63	61	59	57	56	75
44	30	27	24	20	16	12	6	44	76	67	65	64	62	61	59	57	76
45	31	28	25	22	18	13	8	45	77	68	67	65	63	62	60	58	77
46	32	30	27	24	20	16	11	46	78	69	68	66	65	63	61	59	78
47	33	31	28	25	22	18	13	47	79	70	69	67	66	64	62	61	79
48	35	32	29	26	23	20	15	48	80	72	70	68	67	65	63	62	80
49	36	33	31	28	25	21	17	49	*t*.	6°	7°	8°	9°	10°	11°	12°	*t*.
50	37	34	32	29	26	23	19	50									

To determine the dew-point, use the instrument as described, making a note of the readings. Now suppose, for example, that the dry-bulb thermometer stands at 54 and the wet bulb at 45. The difference between 45 and 54 is 9. Find first 54 in the left-hand column of the table, then the number on the same line with it in column 9, table 2. This is 34, the dew-point, or probably the lowest point the temperature will reach during the night. The rule, then, to find the dew-point is: Subtract the reading of the wet bulb from that of the dry; find the reading of the dry bulb in the left-hand column of the table; then on a line with this, in the column showing the same figure as the difference between the wet and dry bulbs, will be found the figures indicating the dew-point.

In whirling the psychrometer some precautions are necessary, lest the instrument be broken. It would be well before actually using the instrument to practice whirling a stick of approximately the same weight. The handle on the psychrometer may be removed and fastened to the stick if desired. If the sun is shining the instrument should be whirled in the shade of a tree or a house, and always out of doors where there is a free circulation of air.

PROTECTION OF PLANTS FROM THE INJURIOUS EFFECTS OF FROSTS AND FREEZES.

As already pointed out, the greatest injury to growing crops from frosts occurs in early spring and autumn. It is possible, of course, to prevent these injuries, but it may not always be profitable or practicable to do so. For example, a 300-acre field of young corn might be saved from severe frost injury, but the cost of the saving would be almost as much as the crop would be worth. Where intensive cultivation is practiced, however, as in the case of tobacco growing, fruit and vegetable growing, etc., it is often practicable to prevent, at reasonable cost, much of the injury that might result if the plants are left exposed. Some of these methods will now be described. It must be remembered, however, that to profit by them careful attention to the suggestions in regard to the foretelling of frosts will be necessary.

Shielding plants by means of straw, soil, etc.—In low-growing crops, such as strawberries and many kinds of vegetables, it is often practicable to prevent injuries from frost by covering the plants with straw, marsh hay, or similar material. Of course it may not always be possible to obtain straw, but where this material is at hand it can be spread rapidly and may result in saving a very valuable crop. Large plantations of strawberries have been covered in this way, the work being continued throughout the night. Although the last plants covered may be slightly frozen, the covering will prevent rapid thawing, and the crop may in this way be saved. Valuable beds of sweet potatoes, tomatoes, and other plants may often be saved, even after

being frozen, by covering with straw before thawing begins and allowing the straw to remain all the next day. Young plants of melons, cucumbers, tomatoes, etc., in the field may frequently be saved by throwing on a light covering of soil with a plow. It requires very little time to run a furrow down the rows of plants, and the soil can be easily and quickly removed by hand the next day or as soon as the danger is past.

Cloth frames are now extensively used by market gardeners and others in protecting beds of young plants in spring from cold and frosts. These frames are usually made of 1 by 3 inch white pine strips. They are 3 feet wide and 6 feet long, and have a brace running diagonally from corner to corner to strengthen them. For a covering, protection cloth, sold by nearly all seedsmen, is used. This consists of oiled muslin of different grades and prices. The best of this material can be bought for about 10 cents a yard. This will make the frames cost about 50 cents each, and with good care they will last for several years. The frames will be found useful for covering hotbeds and cold frames, and offer nearly as good protection as glass. Shallow box frames, about 14 inches square, covered with the protection cloth, are also very useful for covering hills of young melons, cucumbers, etc., in the field. In crops of this kind earliness is, of course, the all-important consideration. If cut back by frosts, the crop is delayed until it has comparatively little value, hence the importance of using every method to bring it in early. The cloth-covered boxes can be made for 5 cents each, and in addition to protecting the plants from cold, winds, and frosts will be found very useful in preventing the ravages of numerous insects which feed on the crop.

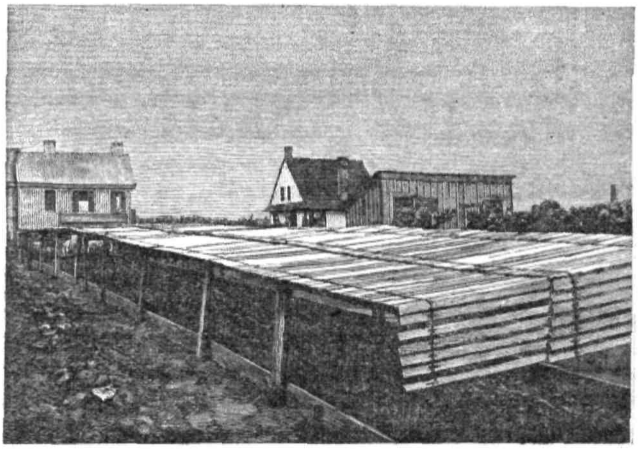

FIG. 10.—Lath screen for protecting plants from frosts.

Screens and wind-breaks.—In many cases plants can be protected from the injurious effects of light or even moderately heavy frosts by sheds or screens made of laths, boards, or other suitable material. Such sheds serve another purpose, that is, shading plants from the hot summer sun. Fig. 10 shows a screen of laths used for shading

plants during summer and for protecting them against early spring and autumn frosts. In this case the laths are fastened to ordinary clothesline wire by means of small staples. When not in use the screens may be rolled up and stored away until again needed.

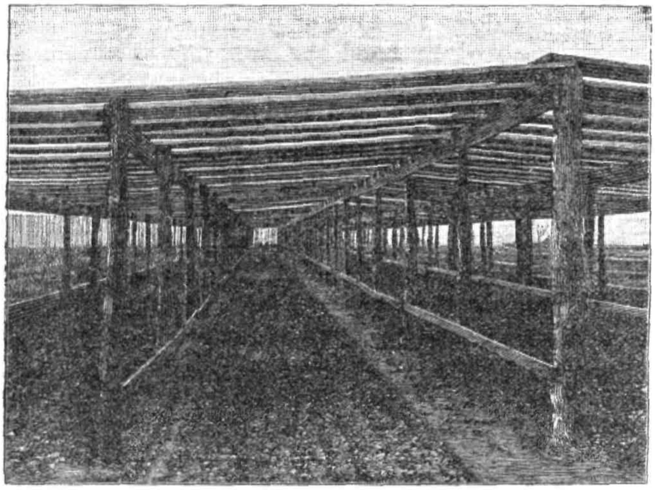

FIG. 11.—Board screen for protecting plants from hot sun and frosts.

Another form of shed is shown in fig. 11. This is made of cheap pine boards 16 feet long and 8 to 12 inches wide. The stringers, as will be seen, are nailed to posts, which are about 7½ feet high. Spaces 4 to 6 inches wide are left between the boards. Sheds similar to these, but usually made of narrow strips, are extensively used in southern Florida for protecting the pineapple against hot sun in summer and cold winds and frost in winter.

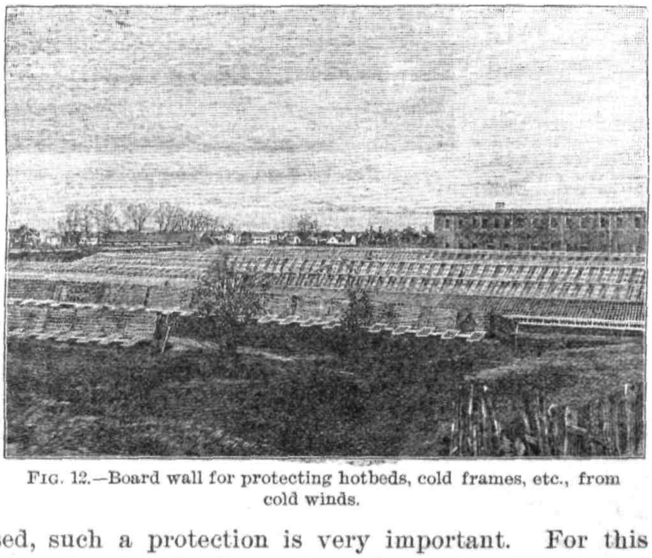

FIG. 12.—Board wall for protecting hotbeds, cold frames, etc., from cold winds.

The injurious effects of cold winds may frequently be prevented by suitable windbreaks. In market-gardening operations, where hotbeds are used, such a protection is very important. For this purpose a tight board wall is built, as shown in fig. 12. The wall is made at the north side of the frames and is from 7½ to 8 feet high. It

is given a slight tip to the north in order to offer better facilities for holding up the straw mats used to cover the glass on cold nights.

Natural or artificial groves of trees may frequently be utilized as wind-breaks. Cedar and arbor-vitæ offer very effective barriers to winds, and where special crops are cultivated in an intensive way such barriers will be found very useful.

Smoke and fire as protection against frost.—On still nights, when the temperature barely reaches 32° F., it is often possible to prevent frost injuries by making a smudge, thus covering the field with a haze, which prevents the rapid loss of heat. Dense smoke can be produced by burning wet straw, wet leaves, sawdust, etc. A mixture of two-thirds sawdust and one-third gas tar makes an effectual material for forming a smudge. The quantities of these materials burned will have to be regulated largely by surrounding conditions. It is preferable to have small fires at frequent intervals rather than large ones more scattered.

Gas tar alone may be used, and in such cases cheap iron kettles are distributed in the orchard, vineyard, etc., the number of kettles being proportionate to the liability of different parts of the ground to frost. The coal tar is placed in the kettles, and whenever indications of frost appear the contents of the kettles are lighted. This is accomplished by a man passing rapidly from kettle to kettle with a torch and a can of benzine or gasoline, a little of this inflammable material being poured into the kettle, and the torch applied. The burning of the tar results in the formation of considerable smoke, and there is also sufficient heat to keep the air in motion. The smudge-pot system is not used as much as formerly, as it does not protect the fruit from a degree of cold much below the freezing point, and furthermore for the reason that the kettles are often burned out before morning, after which time the frost may still prove injurious.

A modification of the foregoing system is used to some extent in certain parts of California. In this case, iron drums, holding perhaps 100 gallons, are placed in rows through the orchard about 100 feet apart in the row. The drums are similar to those commonly used for shipping oil and gasoline. In the orchard they are placed horizontally on framework supports so as to lie about 20 inches above the ground. From each end of the drum a line of gas pipe is laid for some 40 feet along the ground toward the adjoining drums. At intervals of about 10 feet along these pipes are placed iron kettles, which are supplied with crude oil from the main drums. The piping is so arranged as to discharge the oil directly downward into the kettles. The pipes leading out of the drums have stopcocks to regulate the flow of oil into the pipes, and each of the small pipes entering into the kettles is also furnished with a stopcock to control the discharge of oil. When it is apparent that frost is about to

occur, a man passes from tank to tank, opening the supply pipes and regulating the flow into the kettles, at the same time lighting the oil with a torch in the manner already described. The advantage of this system is that the supply of oil is constant and fire can be maintained as long as required. Fig. 13 shows the method of using the system described for preventing frost injuries. There are also some disadvantages which should be mentioned, chief of which is the expense connected with the work. It is also claimed that the fruit is frequently soiled by the smut which rises from the kettles and settles on all parts of the trees.

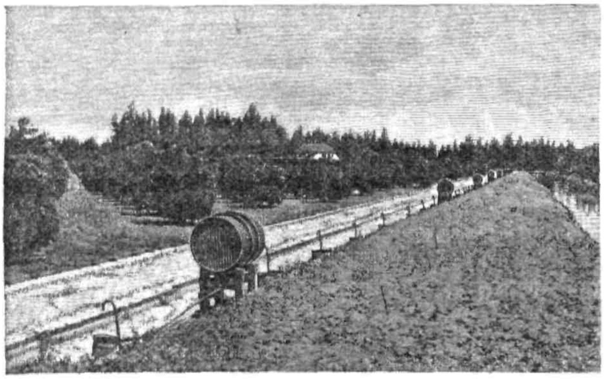

FIG. 13.—Apparatus for smudging orchards.

Flooding, irrigating, and spraying.—The free use of water may often save certain crops from destruction by frosts. The cranberry marshes, for example, are frequently flooded when frost is predicted and thus injury is avoided. Where it is possible to irrigate, frost injuries may frequently be prevented to a large extent. Irrigation in early spring may delay the opening of buds until danger of frost is past. In certain parts of California it is the practice to run irrigating furrows between the trees, and on nights when frost is likely to occur water is run through the furrows. This practice might be followed in other sections where it is possible to obtain water.

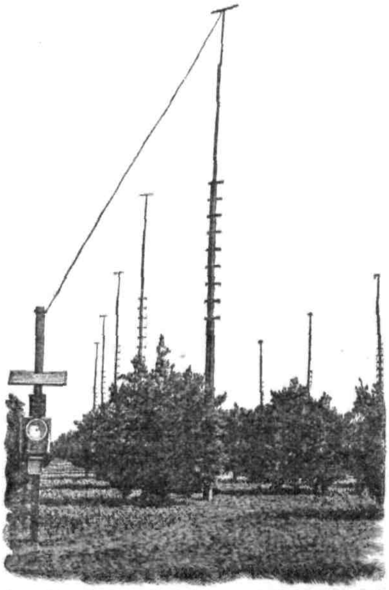

FIG. 14.—Apparatus for spraying orchards with water.

A method used to some extent in California, and which might prove of value elsewhere, is illustrated in fig. 14. This is a system of spraying far above the ground, whereby the air is charged with a fine, foglike mist during the colder parts of the night. To accomplish this,

the orchard is first piped below ground with small pipes. From these, perpendicular pipes are carried up to the height of 40 feet. There are 100 of these pipes in every 10 acres of trees under treatment, or an average of 10 to the acre. They are held in position by passing through the center of wooden supports made in the form of a box. This pole-like box is formed of three parts. The lower third is made of four 6-inch boards nailed together at the edges; the second length, which extends downward through the first as well as far above it, is made of four 1-inch boards, also nailed together at the edges; the third and last length is of two 1-inch boards nailed edge to edge, and is supported by extending down for some distance into the middle length of boxing. Across the top of each perpendicular pipe is connected a pipe of the same size 4 feet long. Each end of this cross-pipe is furnished with a fine cyclone nozzle, with the discharge turned upward. At the base of each main pipe, just above the ground, is a stopcock for regulating the supply of water. All the ground pipes in the orchard unite in one common supply pipe, which passes through the sleeping house of a watchman and connects with the main of the city.

The watchman's house is located on that side of the orchard most subject to injury from frost. It consists of a single room, simply furnished, and is supplied with a telephone connected with the house of the superintendent, as well as with an electric alarm in connection with a thermostat, or alarm thermometer, located in the orchard. When the temperature in the orchard falls to 32° an electric circuit is completed by the contraction of the metallic thermometer, or thermostat, and two alarms are given, one in the room of the watchman and another in the residence of the superintendent, there being wires laid from the orchard to both these places. As soon as the alarm is rung, the watchman, by opening the cock in the supply pipe which passes through his house, can at once turn on the water to all the pipes and spray nozzles. The result is a fog-like mist thrown upward by 100 cyclone nozzles over the entire 10 acres in the block of trees thus protected. This mist soon fills the air to a height of 45 feet, and any stir drifts it about like a bank of fog.

PREVENTION OF INJURIES TO TREES AND OTHER WOODY PLANTS.

The injury to apple and other fruit trees as a result of the alternate freezing and thawing of the tissues has been pointed out. Such injuries are likely to be more severe in seasons of summer drought followed by copious fall rains. During such seasons every effort should be made to conserve the moisture in the soil. Frequent surface cultivation, therefore, is highly important.

In planting orchards the importance of properly selecting soils and varieties as resistant as possible to the effects of drought should be kept constantly in mind. Good results have been obtained in preventing frost injury to the trunks of fruit trees by fixing a board

on the southwest side of the main body. Another very satisfactory method is to train a water sprout on the southwest side of the trunk, cutting the same back so as to form a bushy growth.

Mulching the ground around the trees is frequently practiced with beneficial results. The mulch assists in holding the water in the soil, and also prevents the freezing of the ground around the roots, which latter is frequently the cause of serious trouble to fruit trees, evergreens, and other woody plants. Under the action of cold, dry winds the parts of the trees above ground lose their water, and the roots (being practically unable to obtain a new supply on account of the frozen condition of the soil), the smaller branches, and frequently the large limbs perish from drought.

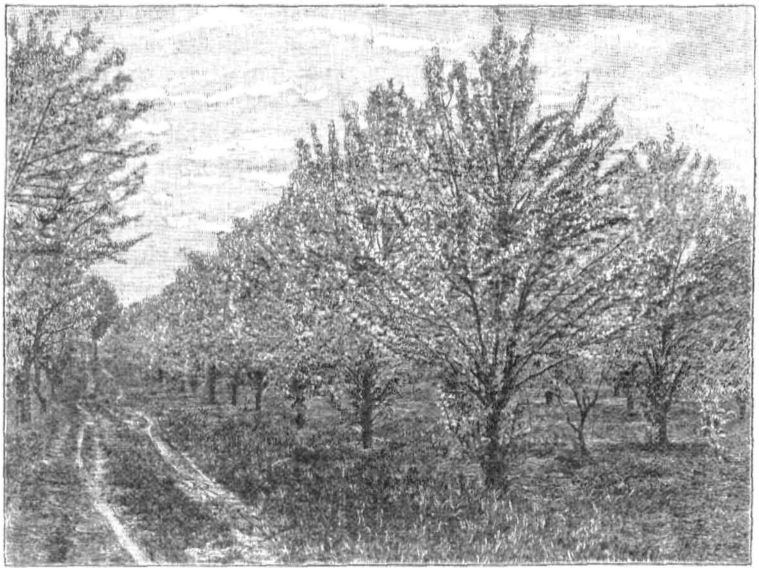

FIG. 15.—Protecting trunks of orchard trees from frost injuries by means of water sprouts.

The effects of fall cultivation, the application in late summer of stimulating manures, and the early defoliation of the trees by the attacks of fungi, have already been briefly referred to. In each of the foregoing cases the tendency is to cause late fall growth, the tissues of which do not have sufficient time to mature, and as a result are killed by the ordinary winter conditions. The remedy, so far as fall cultivation and application of manures are concerned, is plain, viz, to discontinue such methods.

In the case of fungous diseases which cause the loss of the leaves in early summer, spraying with fungicides should be carried on. This work is now so well understood as to require no description here. Suffice it to say that the matter has been very fully discussed in other publications of the Department,[1] to which the reader is referred.

[1] Bulletins Nos. 6 and 7 and Farmers' Bulletin No. 37, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

THE TWO FREEZES OF 1894-95 IN FLORIDA, AND WHAT THEY TEACH.

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RECORD OF FREEZES.

The winter of 1894–95 was rendered memorable in Florida by two of the most severe freezes which have taken place since careful records have been kept. The injuries to the fruit industries were very great, orange, lemon, and many tropical trees being generally killed to the ground in all parts of the State except in the extreme southern portion and on the keys. Certain well-protected localities in the central part of the peninsula also escaped without serious damage, but on the whole, latitude was the only modifying influence of importance. As the blizzards swept southward their severity gradually decreased. Judging from reliable temperature records and from the effects of the cold on vegetation, the isothermal lines in both freezes ran almost directly east and west across the State. From experience and observation in these freezes many important points have been noted as to ways in which plants may be protected against the effects of frost, and the best methods for quickly restoring fruit trees which have been frozen down. These will be discussed in this paper.

On December 27, 1894, the first blizzard began to be felt. This culminated December 29, when the temperature[1] fell to 14° above zero at Jacksonville, one degree lower than during the great freeze of January 12, 1886. The fall in temperature was accompanied by a strong wind, which, at most stations, reached a maximum velocity of from 25 to 30 miles per hour. At most places throughout the northern and central parts of the State killing frosts and freezing temperatures occurred for three days in succession—December 27, 28, and 29. For several days after this blizzard the weather was generally clear and comparatively cold.

The second blizzard, which was very similar to the first, extended over three days—February 7, 8, and 9, 1895. The lowest temperature recorded was on the morning of February 8, when at Jacksonville it again fell to 14°. The reports from stations throughout the orange belt showed a temperature ranging from 16° to 19°. This freeze

[1]All temperature records given in this paper are according to Fahrenheit.

also was accompanied by a strong wind, the maximum velocity of which was from 30 to 35 miles an hour. Killing frosts were reported from almost all stations in northern and central Florida on February 8 and 9, and in various parts of these sections of the State snow and sleet fell. For several days after this freeze the weather was generally clear throughout the State.

The following are the minimum temperatures recorded at various selected stations during the freezes of 1886 and 1894-95, the stations being arranged in order of latitude from north to south:

Minimum temperatures recorded during the freezes of 1886 and 1894-95.

Place.	Latitude.		Minimum temperature.		
			January 12, 1886.	December 29, 1894.	February 8, 1895.
	°	′	°	°	°
Jacksonville	30	19½	15	14	14
St. Augustine	29	53½	17	16	16
Federal Point	29	45	....	17	16
De Land	29	00¾	17[1]	16	17
Eustis	28	51½	18[1]	16	16
Sanford	28	48	21	18	18
Titusville	28	36¾	....	18	19
Orlando	28	32½	19 and 20[1]	18	19
Merritts Island	28	22½	....	22	22
Melbourne	28	05½	....	22[1]	....
Tampa	27	57	....	19	22
Avon Park	27	36½	....	21	23
Manatee	27	30	....	19	23
Jupiter	26	56¼	....	24	27
West Palm Beach	26	43	32[1]	25[1]	29[1]
Myers	26	39	....	24	30
Hypoluxo	26	35½	....	26	32
Key West	24	38½	41.43[1]	44	49

[1] Records are not official.

These records will serve to show the comparative severity of the two freezes of last winter and that of 1886, and the gradual abatement of the severity of each as it progressed southward. From a comparison of the locations given in the table above it will be seen that in any given latitude practically the same temperature prevailed in localities whether in the western part of the State, in the interior, or on the east coast. The Manatee region, protected on the north by the broad Manatee River and Tampa Bay, shows almost the same temperature as Avon Park, in about the same latitude, in the interior, and Melbourne on the east coast. Again, Myers, on the west coast, protected on the north by the broad Caloosahatchee River, and West Palm Beach, on the east coast, protected on the west by the waters of the Everglades, show nearly the same temperature.

Since the blizzards of last winter the fact that killing freezes have occurred before in Florida has been brought prominently to notice.

It is known that severe freezes occurred in the winters of 1747, 1766, 1774, 1799, 1828, 1835, 1850, 1857, 1880, 1884, and 1886, and many lesser freezes are also known to have taken place. Those which were remarkably severe, however, and which are spoken of as "the great freezes," occurred on February 7 and 8, 1835, and January 12, 1886. In the former, the only one which in severity and destructiveness compares with those of last winter, the thermometer, it is said, fell to 8° at Jacksonville. This freeze is reported to have killed orange trees from 40 to 50 years old at St. Augustine and Mandarin. The freeze of 1886 destroyed most of the orange crop, killed young orange trees, and froze all trees back somewhat. Although the damage from this freeze was very great, it was mostly repaired the next year, as the crop that season was larger than ever before. The recorded temperatures of either of the freezes of the winter of 1894-95 are but slightly lower than those of 1886, and consequently either one alone would not have done much greater damage. Their extremely disastrous effects were due to the fact of their having occurred so close together.

From the above statements it appears that many disastrous freezes have occurred in the past, and it is reasonable to assume that similar freezes will take place in the future. It therefore behooves Florida growers to profit by past experiences and take such precautions as are possible to avoid future losses from this source.

EXTENT OF INJURY TO THE CITRUS INDUSTRY.

Damage caused by the first freeze.—At the time of this freeze, December 27-29, 1894, the orange and other citrus trees were largely dormant and the injury was thus not so great. At the time the blizzard occurred it is estimated that there were about 3,000,000 boxes of oranges still on the trees. These, of course, were almost a total loss. When cut open the morning of the 29th, the fruits were found to be a solid mass of ice, the pulp having the appearance of watery snow.

The same was true of all lemons, pomeloes, and other citrus fruits which remained on the trees. The leaves were frozen stiff and rattled in the wind. The vegetation as a whole did not begin to wither until December 30, which was a bright day. Thin, fragile leaves, like the common guava (*Psidium guajava*) and castor-oil bean (*Ricinus communis*), withered very quickly in the sun, but thick-leaved plants, like the eucalyptus, Cattley guava (*Psidium cattleyanum*), and orange, were slow to show the effect of the frost. When protected from the direct rays of the sun, many orange leaves remained green and apparently fresh for five or six days. All leaves were killed, however, except in a few protected groves on the south side of large lakes, like Lake Eustis and Lake Harris, and in the southern part of the State. The leaves did not fall immediately, as is their wont in case of slight injuries, but remained attached to the tree

until about January 7, at which time they were dry and crisp. After this the dropping was gradual, and was caused entirely by outside forces, such as the wind. The fruit began dropping about January 10. This was also very gradual, being caused, as in the case of the leaves, by the wind, etc.

The frozen oranges and pomeloes remained firm and solid for fully a month after the freeze, and were eaten in great numbers and also shipped to Northern markets. It is safe to say that there has never been a time in the history of Florida or America when so many oranges were eaten in so short a time. The cautions of physicians were unheeded, but the result was not disastrous, as many feared. Indeed, such sickness as occurred from eating frozen oranges was unquestionably due to excessive indulgence. Many of the frozen oranges were sent to Northern markets and placed on sale while still juicy and palatable. In some cities their sale was forbidden by the health authorities, who claimed that they were injurious, but this claim has been thoroughly disproved by their extensive use, as above described.

In frozen oranges white specks, frequently as large as half a millimeter in diameter, form in the membranes between the segments and in the membranes of the pulp vesicles. They are so invariably present in frozen oranges, even where the fruit is but slightly injured, that they may be considered as evidence of the effect of freezing. These specks are apparently masses of hesperidin crystals, separated from the cell sap by chemical changes caused by freezing. These characteristic specks are also found in frozen lemons and pomeloes, and probably in all citrus fruits.

The lemon and citron were the first of the citrus plants to show the effects of the freeze. The leaves withered and turned brown in about two days after the freeze, and the fruits became soft and watery, and hung as flabby, misshapen masses as soon as thawed out. Frequently the bark of lemon, citron, and pomelo trees burst open on the trunk, large fissures being formed. Very few sweet or sour orange trees were found to be injured in this manner. Practically all lemon trees in the northern and central portions of the State were killed to the ground by the first freeze. Many pomelo trees were also killed, but others escaped with the loss of most of their limbs.

About January 18 the buds of orange trees began to push, and in a few days numerous sprouts were growing vigorously. By this time the injured wood had become plainly marked in most cases. An examination of many orange groves made at this time showed that small sweet seedlings and budded orange trees were in most cases killed to the ground. The budded trees suffered somewhat more than the seedlings, the point of union between stock and graft being apparently very easily injured. However, it was found that budded or seedling sweet-orange trees which had reached a diameter of from

4 to 6 inches or over were seldom seriously injured. It was also found that where budded trees had reached this size, and the point of union of stock and bud was not injured, the tops were, as a rule, not so much injured as those of seedling trees. The small twigs were killed back from 12 to 18 inches, while the seedlings were apparently killed much farther back. The budded trees of the size mentioned also showed much more vigor in reviving than seedlings, starting growth sooner and growing more rapidly.

The period for two weeks preceding the second freeze was, unfortunately, fine growing weather, the night temperature not falling below 50°, and the day temperature usually reaching 80°. The result was a very rapid growth, especially in budded trees. At the time of the second freeze, commencing February 7, 1895, this growth had reached a length of from 1 to 4 inches, and flower buds were forming on many

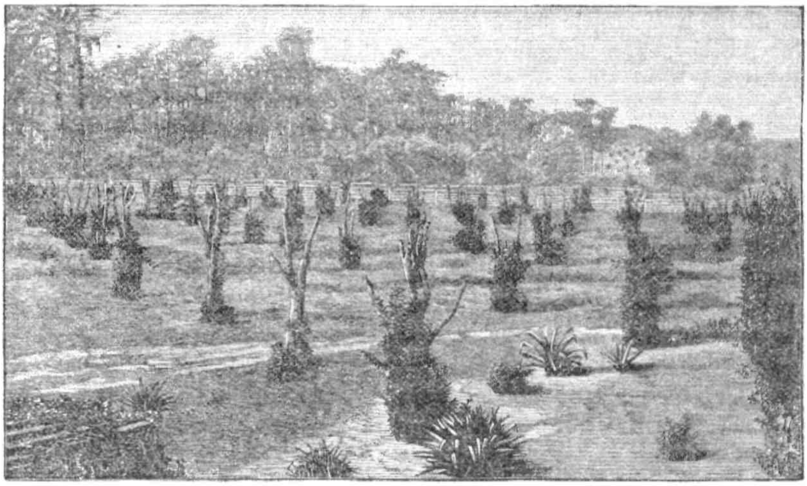


FIG. 16.—An old orange grove killed down by the cold and throwing up sprouts from the base of the trunk. The tops were cut off shortly after the second freeze. Photographed October 25, 1895.

of the trees; the orange groves had begun to look promising, and growers felt much encouraged and were quite elated by the fact that the orange tree had shown itself capable of resisting such a low temperature.

Disastrous results of the second freeze.—Such were the conditions when, on February 7, 8, and 9, 1895, the second blizzard swept over the State. No fruit was now left to be destroyed, but the rapidly growing trees, stripped of their normal dense foliage, were exposed to the full strength of the cold blast, and the little life left was entirely destroyed in many of them. The oldest and youngest trees, whether sweet or sour, were alike killed to the ground throughout the greater part of the State. In many groves this was true of large budded and seedling orange trees from 20 to 40 years old or more (fig. 16), while in

other groves, frequently in the same vicinity, sprouts have been thrown out on the old trunks for some distance up. This is particularly true of hammock groves, which seem to have suffered least.

The extent of the damage to orange trees did not become apparent for some months after the freeze. Many of the large trees threw out sprouts on the trunks some distance up. These struggled along for a time, making considerable growth, but in many cases subsequently died back entirely, the bark having been killed below. This sprouting out and dying back continued more or less throughout the summer, but the growth which remained healthy until July has in most instances continued to the present time (November 1, 1895).

The effect of water protection was in many cases very noticeable. In groves on the south side of Lake Harris and Lake Eustis, for instance, several rows of trees nearest the water retained some of their leaves, and the effects of the protection afforded was apparent for about half a mile back from the lakes. On Terraceia Island, in Tampa Bay, even lemons escaped unhurt, and in some groves on the mainland bordering on the bay orange trees were almost entirely unharmed and lemon trees only slightly injured. Passing away from the bay, however, the effect of even this broad expanse of water gradually disappeared, being hardly noticeable 2 miles distant. The orange groves south of Braidentown and Manatee, and 2 miles distant from the broad Manatee River, were about as badly injured as groves in the interior of the State in the same latitude.

The effects of the freezes were also considerably ameliorated by forest protection. This was particularly noticeable in groves where large numbers of palmettoes and some oaks and magnolias were allowed to stand among the orange trees. Again, thick wind-breaks perceptibly protected a few rows of trees nearest to them.

Orange trees not protected were injured as far south as Myers (26° 39′). The damage south of the twenty-seventh parallel of latitude, however, was not serious, consisting merely of injury to a few of the top leaves and young branches. The mandarin, tangerine, and Satsuma oranges (*Citrus nobilis*) in general suffered about the same as the common sweet orange. The pomelo and shaddock (*C. decumana*) are much tenderer than the orange. The large pomelo trees which were not killed by the first freeze were almost invariably split open and killed to the ground by the second. It is difficult to find a tree where any portion of the trunk was saved. In well-protected regions, like Palmetto, trees which lost all leaves and many branches are in some cases bearing fruit this year. At Bartow the trunks of some of the large trees were saved, and in the town of Myers, which has good water protection, the trees were practically uninjured. East of Myers, and farther away from the river, they were injured, but not seriously. At Jensen buds 3 years old were killed down. The latitude below which the pomelo escaped serious

injury can hardly be determined, owing to lack of trees from which to judge. It can probably be placed at about 26° 30′. Lemons (*C. limonum*) and limes (*C. limetta*) throughout the northern and central parts of the State were killed to the ground. In the Manatee River region the trees, when near the water, were not seriously injured; at Myers they suffered but little; at Palm Beach they escaped injury; and south of the twenty-sixth parallel they evidently were not severely affected. Every citron (*C. medica*)[1] and kumquat (*C. japonica*) in the State, so far as known to the writer, was killed. In the extreme southern part of the State they would probably have escaped serious injury. The trifoliate orange (*C. trifoliata*) is the only citrus species which escaped injury from the two freezes.

LESSONS TAUGHT BY THE FREEZES.

The experience of last winter has taught some valuable lessons as to ways by which the extent of damage caused by severe freezes may be lessened. In a few cases where growers had banked their trees up some distance around the trunk with earth, covering the union of bud and stock, it was found that the buds and a portion of the trunk were saved. This shows that it would unquestionably be a wise policy to make a practice of banking up the trees every winter in this way, say by the middle of December, removing the soil about the 1st of March. The expense of doing this would be very slight, probably not more that one-half cent per tree. Care should also be taken to have the point of union between the stock and bud or graft near the soil. On thoroughly drained, porous soils there is no objection to having the union slightly below the surface. This would insure the safety of the buds in the most severe freezes, especially if the trees were slightly banked. On poorly drained soils, where the trees are subject to foot rot, sour-orange stocks, budded above the ground, should be used. When lemon or pomelo stock is used, the union should by all means be placed low, as these stocks are very easily injured by cold.

Careful observations have shown that the method of training the trunk is also important. Trees having a single main trunk were much less injured by the cold than those of the same size growing under similar conditions but having several trunks. This was quite noticeable in protected regions after the first freeze, but of course the two freezes in most places were enough to kill almost any trunk. This shows clearly that where possible it is very desirable to train the trees so that a single main trunk is formed up as high as is consistent with a well-shaped tree. By following this rule a much larger trunk can be saved in case of a severe freeze (figs. 17 and 18).

Dividing groves into small plats of 4 or 5 acres and leaving windbreaks between and surrounding these has also proved to be a good practice. This can easily be done by leaving strips of the original

[1] Since this paper was written uninjured citron trees have been seen by the writer at Cocoanut Grove and Elliotts Key.

forest when clearing the ground. In many hammock groves in which palmettoes, magnolias, and other forest trees were allowed to stand among the orange trees, the protection they afforded was plainly noticeable. Where the soil is rich enough to allow of this method of culture, it should be adopted as a protection against cold and frosts.

Several groves, in various parts of the State, were protected to some extent by fires distributed through them at regular intervals. These fires were made by lighting brush piles already in the grove, or by distributing and igniting pots of resin prepared for this purpose. The trials made of these methods were fairly successful, and indicate that much can be gained even from the little protection thus afforded. During light freezes in the northern part of the State the fruit has often been saved by such fires.

The well-recognized slight differences in hardiness shown by varieties of oranges was scarcely perceptible in the last hard freeze. In

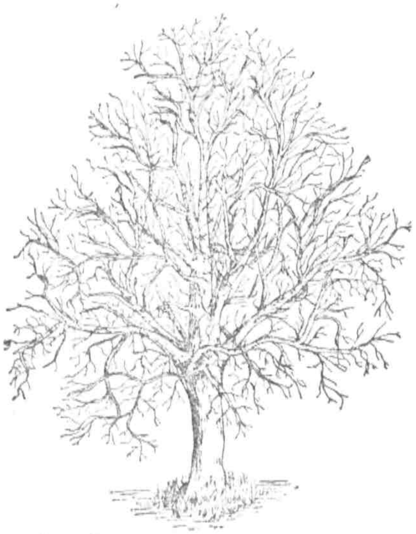


FIG. 17.—A properly trained trunk.

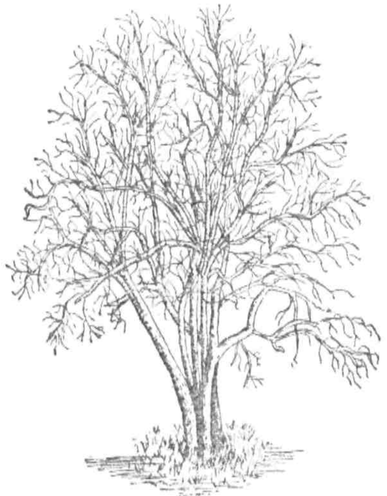


FIG. 18.—An improperly trained trunk.

protected regions, like Palmetto and Braidentown, and in the southern part of the State, however, some difference could be observed. Harts Late is reported by most growers to have withstood the cold better than any other variety, and the Jaffa and Majorica were also found to be quite hardy. The Mediterranean Sweet proved to be very tender, and the Satsuma, which was supposed to be very hardy, usually suffered as much as the tangerine. When on *Citrus trifoliata* stock, however, the Satsuma is reported to have withstood the cold better.

RESTORATION OF FROZEN ORANGE GROVES.

After it became apparent that most citrus trees were killed back nearly or quite to the ground, the question as to what treatment was best under the existing conditions came to be an important one with

growers. The experience gained in the freeze of 1886 was of little value, as at that time the trees were not, as a rule, severely injured, and the lessons taught by the freeze of 1835 had been largely forgotten and were too indefinite. The result was that many different treatments were followed.

The time and manner of pruning the frozen trees were puzzling questions. From the experience in the freeze of 1835, it was claimed by some growers that if the dead top was not cut off the fermenting sap would pass down and kill the living portion of the trunk and the roots. This belief, however, has been disproved by extensive experience since last winter's freezes. As yet hundreds of groves remain unpruned, and in no case do the trees show any injurious effect that can be traced to this cause. Indeed, many growers claim that the protection and slight shade afforded by the old top has been decidedly beneficial. The sprouts on such trees have unquestionably grown higher than on pruned trees, but are usually slender and unbranched, probably due to the effect of the shade. Trees which were pruned back into the living wood early in the season have made a more general and bushy growth, and will probably ultimately make the best-shaped tops. As a whole, little difference can be seen between early pruned trees and those left unpruned. The sprouts in unpruned trees have grown so large now (November 1, 1895), however, that many will be destroyed or injured by even the most careful pruning. Probably the best practice is to prune the trees as soon as the sprouts have started and show a healthy growth, cutting the trunk below the upper sprouts down to a short distance above where the most healthy, vigorous growth appears. Where the trees were killed to the ground, many cut them off below the soil and covered the cut surface with earth to protect it from the hot rays of the sun. In general this did not prove as satisfactory as allowing the tops to remain until the sprouts started. Where the trees were slow in sprouting, removing the dirt from around the trunk and crown roots, thus exposing them to the sun and air, proved efficient in inducing sprouts to start.

The practice most generally followed throughout the State with trees killed below the buds was to allow sprouts to come up from the base of the trunks or from the roots and bud them as soon as they reached sufficient size. The budding of the sprouts was commenced in May and continued throughout the season as the sprouts attained sufficient size. The buds put in during May have now, as a rule, reached a height of from 4 to 7 feet (fig. 19).

Many growers have allowed all the sprouts to grow that started, intending to dormant bud the largest this fall or bud early next spring. In cases where the trees sprouted early, and the necessary buds could be secured, this would seem to be a waste of valuable time.

The practice of crown grafting trees killed to the ground has been followed to some extent, and when properly done has proved an

excellent method. In this case the trees were cut down below the surface of the soil to where the wood was sound, and the scions inserted. The scions should be of sound, mature wood, about 5 inches long, sharpened by a long, slanting cut on one side, as shown in fig. 20, *a*. Several grafts should be inserted on each stock to make sure that at least one will grow. The grafts should be pushed down between the wood and the bark, as shown in fig. 20, *b*. The best place to insert the grafts is in the concave portions of the trunk, as here the bark can be pressed out without breaking in order to allow the insertion of the scion. The bark will hold the scion firmly against the stock, and in this way no wrapping is required. Moist dirt is then thrown up over the grafts, allowing simply the upper end to protrude. The use of grafting wax on scions inserted in this way is said to be unnecessary. If the trees are not cut below the ground it would probably be desirable to place small strips of waxed cloth over the cavity formed between the bark and the wood.

FIG. 19.—Ruby orange bud, put in May 21, on sprout from old sweet-orange trunk. Photographed October 25, 1895.

In the use of this method, however, many failures have been made, evidently due to cutting the trees too high. Cutting below the soil, even though some of the large crown roots had to be sacrificed, seemed to be the best way. The benefit derived from the use of this method is that of securing in the graft all the growth made. The grafts may be put in promptly after a freeze, or as soon as the bark can be made to part for their insertion. The graft heals on before growth usually starts and has buds formed ready to push in the spring, while if the trees are allowed to start of their own accord adventive buds must be formed before the sprouts start. Grafts properly inserted started earlier than the sprouts, and as a rule made a much larger growth than sprouts which grew from the roots of similar stocks. Cutting back the sprouts to force the buds, in the practice of sprout budding, puts the growth back and again weakens the roots, already nearly dead. This is prevented by grafting, by which means all the growth made is thrown into the grafts which are to

remain. Crown grafts put in immediately after the second freeze are as a whole six months in advance of the best growth made by buds put in on sprouts from the roots, and are fully a year in advance of many of the groves of the State which have been slow to start sprouts and thus could not be budded. Grafts on old and young stocks take equally well (fig. 21).

Nursery stock and small trees killed down by the freeze were apparently built up with the least loss of time by cutting them down below the soil 1 or 2 inches immediately after the freeze, and cleft grafting them by the common method, as illustrated in fig. 22. This method was not practiced sufficiently to warrant a positive statement that it is the quickest. The almost universal practice was to allow sprouts to grow from the roots and to bud them as soon as they had

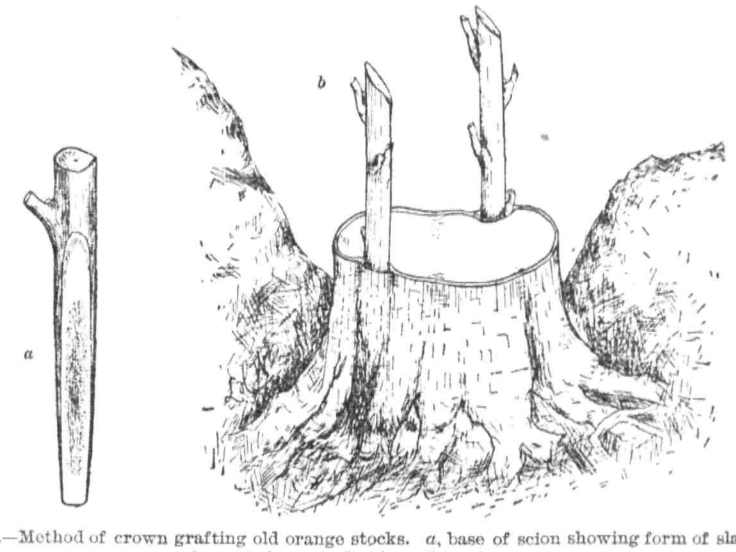


FIG. 20.—Method of crown grafting old orange stocks. *a*, base of scion showing form of slanting cut; *b*, method of inserting scion.

reached sufficient size. The greater handiness of this latter method recommends it in this case, where at best little difference can be expected.

By means of inarching, many growers are throwing the strength of several sprouts into the one which is budded. Although tedious, this practice is desirable to hasten development. It necessitates rather high budding, however, which should be avoided if possible.

DAMAGE WHICH THE FREEZES CAUSED TO PINEAPPLES.

The pineapple industry, which in southern Florida has reached considerable importance and probably ranks second among the fruit industries of peninsular Florida, was also severely injured by the

freezes of last winter. In the northern part of the pineapple section all plants, covered and uncovered, were killed to the ground, and as far south as Biscayne Bay all uncovered plants were injured. The damage to the pineapple industry was proportionally less than to citrus fruits, as at the time of the freezes the pineapple crop had been marketed, and, besides, it does not take the plants so long to recover. Moreover, the expense and delay in budding or grafting necessary in citrus trees are not required in these plants. This season the crop was very small and the fruit formed was of inferior size and quality. During the season of 1894 the Jacksonville, St. Augustine and Indian River, and the Savannah, Florida and Western railroads carried 82,708 whole or barrel crates, while in 1895, the season following the freeze, the same roads carried only 17,093 crates. From present indications the yield of the summer of 1896 will probably be as heavy as ever before. The only loss, however, even in these exceptionally severe freezes, was one crop of fruit and the cultivation for one year.

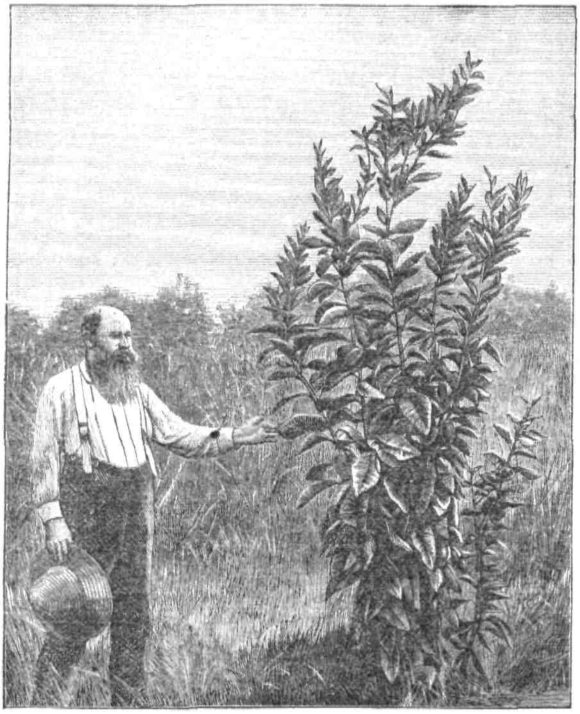


FIG. 21.—Ruby orange graft on old sweet-orange stock, put in March 1 by crown-graft method. Photographed October 23, 1895. (Compare with fig. 19.)

During both freezes ice was formed in the centers of almost all the pineapples as far south as Palm Beach, and the leaves were frozen stiff; most plants grown outside of sheds were killed to the ground as far south as West Palm Beach and Myers. A few localities having extensive water protection, like Sewalls Point, escaped with but little injury. At West Palm Beach plantations bordering on the fresh-water lakes

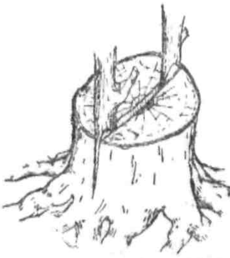


FIG. 22.—Cleft grafting.

of the Everglades were scarcely injured. A quarter of a mile away from the water, however, little benefit could be observed. At Biscayne Bay (25° 45′), nearly one degree south of West Palm Beach, the damage to plants outside of sheds was noticeable, but not serious. The crowns of the fruits were injured and the foliage somewhat damaged, but the development of the fruit was not impaired. Plants grown under sheds were severely injured in the northern part of the pineapple section, but may be said to have practically escaped injury south of the twenty-seventh parallel.

Old pineapple plants which had fruited and suckered, being mainly above the ground, were most seriously injured. The buds of such plants were in most cases killed, but suckers and ratoons[1] were formed from the base, so that the fields were largely replaced without replanting. Plants which had not fruited were much less injured, probably owing to the fact that in plants set out the bud is placed lower in the soil. Such plants did not lose their buds, and in some cases retained a few of the central leaves uninjured. Young plants set in July and August of last season (1894) did not lose their buds. These have grown rapidly this summer, and from their size now (November 1, 1895) it is almost impossible to tell that they were injured.

Little difference could be observed in the hardiness of the different varieties, other than that due to the difference in size. The large plants were usually the least injured. Thus the Porto Rico, the largest variety grown, was probably the least injured. The Abbaka and Spanish probably come next in the order of size and consequent injury, but the difference is very slight.

EXTENT OF INJURY TO OTHER FRUITS.

Guavas (*Psidium guajava*) were greatly injured by the two freezes, being frozen to the ground throughout most of the State. At Myers the plants suffered considerably. On the west side of Lake Worth they were slightly injured, but on the east side of the lake, at Palm Beach, they were generally unharmed. At Biscayne Bay they escaped entirely. The Cattley guava (*P. cattleyanum*), although much hardier than the common guava, was almost as badly killed down in these severe freezes. At Jensen all plants of this variety were killed to the ground, but at Palm Beach they escaped injury. Though one of the tenderest fruits grown, the guava recovers so rapidly from injury that it has been quite generally planted as far north as 29°. All guavas frozen down have sprouted abundantly from the base and have made a vigorous growth this summer (1895). They will bear a fair crop next year, the second season after freezing down.

The cocoanut palm (*Cocos nucifera*), which is grown quite extensively from Eden south, on the east coast of Florida, and at Myers, on

[1] Suckers starting from the old stem from below the soil.

the west coast, suffered severely in the northern parts of these localities. At Eden, Palm Beach, and Myers all the leaves were killed. On most of the trees, however, the buds remained uninjured, so that new leaves were thrown out in the spring and the majority of the plants are rapidly recovering from the damage done. At Palm Beach the buds of about 5 per cent of the plants were killed, so that they have not started (see Pl. III). Like many other monocotyledonous plants, if the apical bud of the cocoanut palm is killed the trunk will die, as it is not able to form a new bud. At Biscayne Bay even the leaves were practically uninjured.

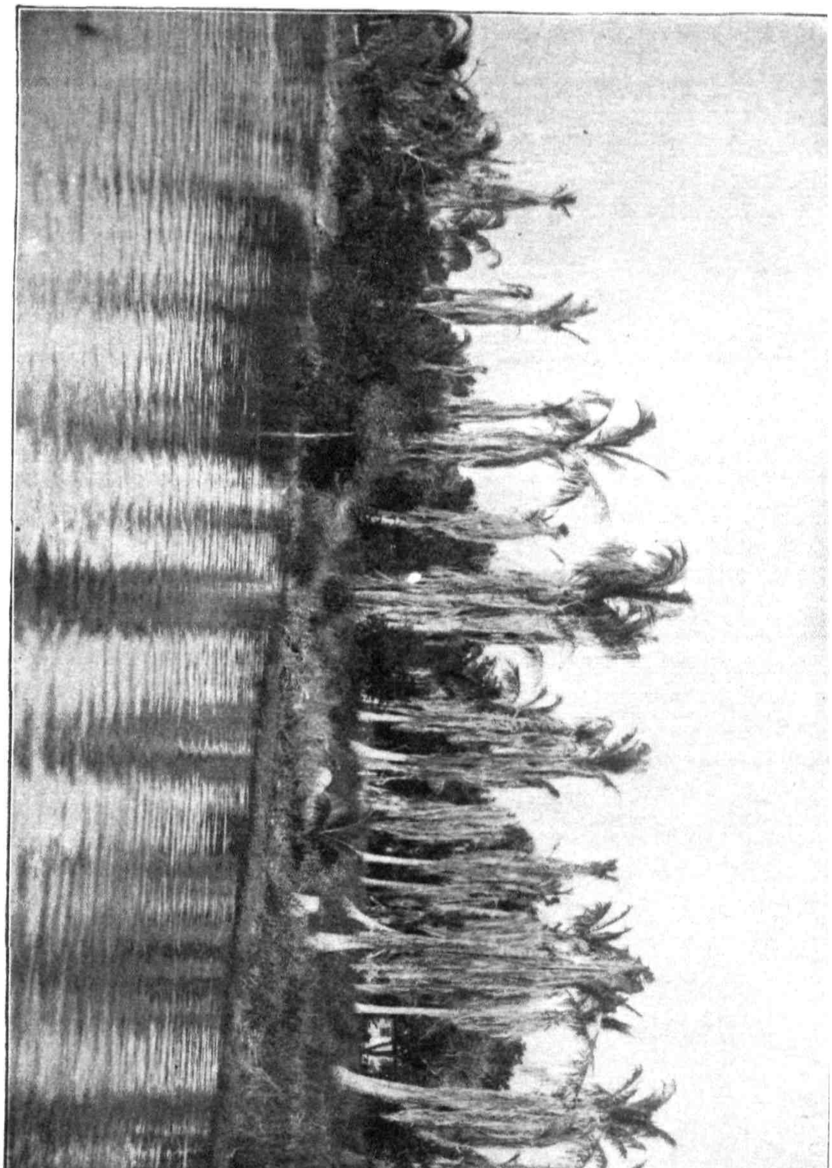
The mango (*Mangifera indica*), which is quite extensively grown in the southern part of the State, was severely injured as far south as Palm Beach and Myers. Here the plants lost most of their leaves and the branches were killed back from 2 to 4 feet. At Eden, Manatee, and St. Petersburg large trees were killed to the ground. The trees, however, have shown great vigor in recovering, sprouting readily from the base of the trunk or from large uninjured limbs.

The banana (*Musa*), sapodilla (*Achras sapota*), sour sop (*Anona muricata*), sweet sop (*A. squamosa*), cherimoya, or Jamaica apple (*A. cherimolia*), Spanish lime (*Melicocca bijuga*), Otaheite gooseberry (*Cicca disticha*), and other strictly tropical fruits were killed almost to the ground at all places in the State other than the extreme southern portions.

EXTENT OF INJURY TO NATIVE VEGETATION.

The native plants of Florida were in general but slightly injured. The plants which suffered severely were principally those of tropical origin, which have spread into southern Florida from the West Indies and Bahamas and thence northward as far as thermal conditions permit. These plants are limited principally to the keys and hammock islands along the coast.

The mangrove (*Rhizophora mangle*), which forms dense thickets on the tide-washed islands and on the shore as far north as Ormond (29° 22′), was killed down as far south as Lake Worth, except in cases where the plants grew on the south side of large bodies of water. At Myers, however, trees bordering on the south side of the Caloosahatchee River were killed. As the mangrove is one of the most valuable honey plants in Florida, its destruction is a great loss to bee keepers. The sea grape (*Coccoloba uvifera*) also suffered severely, large trees being frozen down at Manatee. At Palm Beach, however, they were only slightly injured. The satin leaf (*Chrysophyllum oliviforme*), probably having the most beautiful foliage of any native tree of Florida, was frozen down about Rockledge, its northern limit, and was seriously injured as far south as Palm Beach. Rubber or wild fig trees (*Ficus pedunculata* and *F. brevifolia*), which are abundant in the island and coast hammocks as far north as



COCOANUT GROVE NEAR PALM BEACH, FLORIDA, SHOWING EFFECTS OF FREEZE.

Rockledge, were considerably frozen back as far south as Palm Beach and Myers. The gumbo-limbo (*Bursera gummifera* Jacq.) and satin wood (*Xanthoxylum pterota*) were also among the seriously injured plants. Water lettuce (*Pistia spathulata*) and water hyacinth (*Eichornia speciosa*), which are very abundant in many ponds and sluggish streams, were frozen down to the water level.

Considering the severity of the freezes of last winter, it is indeed remarkable how slightly the majority of the native plants were injured. The plants of Northern origin growing in the high pine lands, flat woods, scrubs, and hammocks of the interior were almost all unharmed.

SUMMARY.

(1) The first freeze, December 27–29, 1894, caused a loss of some 3,000,000 boxes of oranges and lemons, killed many young citrus trees, and seriously injured old trees. Guavas, pineapples, and many tropical fruit trees were frozen down throughout the northern and central portions of the State.

(2) At the time of the second freeze, which culminated on February 8, 1895, the citrus trees which were not killed by the first freeze had started to grow vigorously. The result was that trees of all varieties and sizes were killed to the ground throughout the State, except in the extreme south and in a few protected localities.

(3) The frozen oranges and pomeloes were eaten in great numbers and large quantities were also shipped to Northern markets, and the fact that no injury resulted from the unprecedented comsumption disproves the claims of many physicians and health authorities that such frozen fruit is unhealthful. In the membranes between the segments of frozen oranges white specks were so invariably present as to be satisfactory evidence of freezing.

(4) Where orange and other citrus trees had been banked with earth around the base before the freezes, a portion of the trunk was saved. This practice is thought very desirable in order to protect the point of union in trees budded or grafted near the ground. Budding or grafting trees near the ground or below it is a good preventive against loss by cold, and should be invariably followed, except on low, poorly drained soils, which are subject to foot rot. When the point of union is placed below the soil the bud is generally safe from injury, even in the most severe freezes, and if near the ground it can easily be protected by covering with earth.

(5) Citrus trees having a single main trunk were found to endure the cold much better than trees of the same size having several trunks, and therefore wherever possible trees should be trained so as to form but one trunk as high up as would be consistent with a well-shaped tree. Wind-breaks and forest trees scattered among the fruit trees proved beneficial. Protection of this kind can be provided for when clearing the ground, by leaving strips of the original forest

around plats of, say, 4 or 5 acres, and a tree here and there through the plats. Fires scattered through the groves were also markedly beneficial. Losses from freezing can also be overcome to a slight extent by planting hardy varieties, as some kinds withstand low temperatures better than others.

(6) Little difference was apparent in frozen trees whether pruned soon after the freeze or left unpruned. Apparently no injurious effects resulted from leaving the frozen tops attached, but it is thought that in general early pruning gave rather the best results. Probably the best time to prune the trees is when the sprouts have started and show a healthy growth. The trees should be cut below the upper sprouts down to a short distance above where the most healthy and vigorous growth appears. In restoring orange and lemon groves frozen to the ground, the method of cutting the trees off below the soil and crown grafting has proved much better and quicker than waiting for sprouts to grow from the base and budding them when they had reached sufficient size. What appeared to be the quickest way to build up nursery stock and small trees killed down by the freeze was by immediately cutting them 1 or 2 inches below the soil and cleft grafting them.

(7) Pineapples were injured as far south as Biscayne Bay. Plants which were grown under sheds were not seriously injured south of the twenty-seventh parallel. The pineapple plants will entirely recover from the injuries of the freezes in one year.

(8) Strictly tropical fruits and plants were badly injured in all places in the State, except in the extreme southern part, that is, at Biscayne Bay and on the keys. The native vegetation, particularly plants of Northern origin, was but slightly injured.

(9) Large bodies of water afforded great protection to citrus trees growing in their vicinity. Except in the southern part of the State the first freeze killed the foliage on all trees outside of those growing on the south side of large lakes, where the results of the tempering influence was perceptible for half a mile from the water. On Terraceia Island, in Tampa Bay, even lemons escaped unhurt, and orange groves bordering on the mainland of this bay were almost entirely unharmed. The beneficial influence of this large body of water extended 2 miles. Pineapples, guavas, etc., grown in regions having extensive water protection escaped much of the damage sustained by such fruits when grown in the same latitude but away from any body of water.

TESTING SEEDS AT HOME.

By A. J. Pieters,
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THE IMPORTANCE OF HAVING GOOD SEED.

The importance of seed testing is recognized not only by professional seedsmen, but also by intelligent farmers. The necessity for testing seed arises from the fact that not every seed contains a living germ. The absence of a living germ makes the seed useless for the reproduction of its kind. To find out what proportion of the seeds in a sample contains germs capable of growth is therefore the object of all seed testing.

Good seed is essential to successful agriculture. No matter how well the farmer prepares his land; no matter how much time, labor, and money he spends on it, if much or all of his seed fails to "come up" he will either have a poor crop or will be obliged to reseed, thus losing time and labor. Many causes may contribute to prevent him from getting a good stand, but if he can eliminate any one of these he is by so much the gainer. Poor seed is a great cause of poor stands.

The farmer and the gardener get seed from one of two sources—they either grow it themselves or buy it. If the former, there is less danger of its being poor. The chief source of poor seed is careless handling in harvesting and storing. If seed gets too damp, mold will destroy much, or the seed will begin to sprout, then dry out, and the germ will be killed. If seed is bought, the chance of getting a poor quality increases many fold. If all seed was bought from reliable dealers, there would be far less cause for complaint, but farmers too often buy seed where they can get it the cheapest. They pay their money for trash that is either full of harmful weed seeds or has a liberal admixture of old and dead seeds.

Whenever large quantities of seed are purchased, they should be tested for purity and germination. The table on the following page gives the result of a few tests out of the many that were made in the Department seed laboratory last year of seeds bought from supposed reliable seedsmen.

The old adage that a dollar saved is a dollar earned will apply to the purchase of seeds. It is an easy matter to waste a dollar on seeds, and when profits depend upon cutting down useless expenditure, the use of inferior seed can not be too strongly condemned.

Germination tests of seeds.

Kind of seed.	Per cent of germination was—	Per cent of germination should be—
Bean, Burpee's bush lima	72	95
Bean, Dwarf, pink-eyed wax	77	95
Cabbage, Drumhead	67	95
Cabbage, Luxembourg	67.5	95
Carrot, Mastodon	58	85
Clover, scarlet	4	90
Japan	5	76
Corn, Egyptian sweet	76	92.5
Corn salad	39	80
Cucumber, White wonder	72	92
Eggplant, New York improved thornless	62	85
Grass, Kentucky blue	10	50
Orchard	31.3	80
Texas blue	1	50
Lettuce, Golden ball	64.5	90
Muskmelon, Shumway's giant	69	92
Muskmelon, Surprise	64	92
Onion, Early round white Dutch	58.5	85
Oats, Scotch white	79.3	95
Parsley, Beauty of the Parterre	53	75
Pea, Dr. McLean	88	98
Pepper, Cranberry	42	85
Pumpkin, Winter luxury	65	92
Radish, Chartier	63	95
Rape, Dwarf Essex	79.5	95
Salsify, Sandwich Islands	49.5	83
Spinach, Mett's crumpled leaf	43.5	89
Tobacco, White burley	0.25	88
Tomato, Lorillard	72.5	90
Watermelon, Cole's early	88	92

The standard of germination in oats is 95. This places the normal loss from nonviable seeds at one-twentieth part. In the sample of oats reported in the table the loss was slightly more than one-fifth. There was four times as much waste in this sample as there should have been. The White Dutch onion seed germinated 58.5 per cent. The loss in this case was 1 pound in every $2\frac{1}{2}$, while the normal waste should have been less than 1 pound in 7. The loss on Egyptian sweet corn reached $1\frac{1}{4}$ pecks in 5. The normal loss should not exceed 1 peck in 13.

A farmer sowing a meadow to Kentucky blue grass and buying such seed as that reported in the table would pay for 9 bushels of dead seed out of every 10 bushels purchased. There is always a great deal

of loss in this as in most grass seeds, but it should not exceed 5 bushels in 10. Here is a clear loss of 4 bushels out of every 10 bought, which, at $1.65 per bushel, is worth considering. The normal waste in orchard grass seed is 1 bushel in 5, but the sample tested contained almost 3½ bushels of worthless seed out of 5. At present orchard grass brings about $2 per bushel. This makes a net loss of about $7 on a purchase of 5 bushels of seed. It is unnecessary to give other examples of the loss which farmers suffer by purchasing poor seed. The table affords ample illustration.

METHODS OF TESTING SEEDS.

Many seedsmen and a few farmers test their seeds. The method generally followed is to throw a handful of seed into a box full of earth, and decide by the way it comes up whether the seed is good. This is better than no testing at all, but it is impossible to get accurate results in this manner if the seeds used are not counted.

Another method is to make a shallow trench in sand, scatter in the seeds as thickly as is recommended for the variety, and wet with warm water. The seeds germinate rapidly, and the merit of the sample is judged by the stand in the row. When the seeds are not counted, no accuracy is possible. Besides, it is well known that the amount of seed thought necessary per running foot of drill, or per acre, is from two to four times as much as would be required if the seeds used had a high vitality.

Some people think that if seeds are thrown into water the good ones will sink and the dead seeds will float, but this notion is not supported by facts. When seeds float it is often because an air bubble has become attached to them or because they have not become wet all over the surface. Several experiments were made to test the germination of seeds that sink and those that float. Wheat was used in one set of experiments, and the average of all tests showed a germination of 68.3 per cent for the sunken seeds and 72 per cent for those that floated. In another set of experiments lentil was used, and it was found that 75.4 per cent of the sunken seeds and 86.7 per cent of those that floated germinated.

The germination of seeds depends on a proper supply of heat and moisture. For accuracy in testing, darkness is also essential. Seeds will germinate through a considerable range of temperatures, but the number of germinating seeds decreases as we depart from the optimum, or most favorable, temperature. If seeds are subjected to temperatures higher or lower than the optimum, germination will proceed more slowly, and when either extreme is passed it will cease. All seeds do not have the same temperature limit. Seeds of tropical plants need more heat to germinate than those from plants growing in northern latitudes or on high altitudes. Certain seeds have been known to germinate upon ice. Nobbe records an observation by

Uloth on the root of a maple seedling which penetrated a short distance into solid ice. Wheat has been known to germinate at the freezing point.

The following table, showing the effects of given temperatures upon the germination of seeds, is taken from Nobbe's Handbuch der Samenkunde. The column under *a* indicates the number of seeds germinated; that under *b* shows the number of hours required to germinate that number under the fixed temperature.

Seed.	16° C. (60.5° F.).		25° C. (77° F.).		31° C. (88° F.).		37.5° C. (100° F.).		44° C. (111° F.).	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Barley	100	72	92	72	24	144	-----	-----	-----	-----
Buckwheat	100	72	100	24	100	24	100	48	-----	-----
Cabbage, early, small	100	56	100	32	100	48	-----	-----	-----	-----
Cabbage, late, large	100	48	100	24	100	48	-----	-----	-----	-----
Clover, scarlet	100	32	100	24	100	24	100	24	-----	-----
Clover, red	100	32	100	24	100	24	100	24	-----	-----
Corn (maize)	80	144	68	56	100	48	100	48	12	80
Cucumber	76	216	100	96	100	32	100	48	60	120
Flax	100	32	100	23	100	47	-----	-----	-----	-----
Lucern	100	32	100	24	100	24	100	24	-----	-----
Muskmelon	4	200	100	120	100	48	100	48	20	96
Oats	100	80	100	48	100	80	-----	-----	-----	-----
Radish, round, white	100	32	100	24	100	32	100	48	36	96
Radish, long, white	100	192	100	48	84	96	-----	-----	-----	-----
Rye	100	56	100	32	100	80	-----	-----	-----	-----
Rye grass, English	100	216	100	120	100	72	-----	-----	-----	-----
Sunflower	100	32	100	32	100	24	100	48	-----	-----
Timothy	76	168	100	144	88	148	-----	-----	-----	-----
Tobacco	100	192	100	108	88	168	-----	-----	-----	-----
Wheat	100	56	100	32	100	48	-----	-----	-----	-----

PROPER CONDITIONS FOR TESTING SEEDS.

The best temperature for the germination of most seeds is shown to be 25° C. (77° F.), while for a few this optimum is 31° C. (88° F.) and 37.5° C. (100° F.). But seeds germinating under natural conditions seldom have the advantage of this optimum temperature.

In testing seeds, therefore, since it is necessary to get as near the natural conditions as possible, the temperature should be kept at between 18° and 20° C. (64° and 68° F.). This has been found to be the normal temperature for germination. Usually the heat of an ordinary living room will be sufficient for home testing, but if the temperature is likely to fall very low during the night it is better to provide a little heat during that time. More harm will result from a considerable decrease of temperature than from a slight increase. In the European seed-control stations seeds are tested at a constant temperature of 18° to 20° C. (64° to 68° F.). For grass seeds the temperature is forced up to 30° C. (86° F.) during six hours of the twenty-four, this variation in the heat being found advantageous.

Moisture is as important as temperature. Before a seed can sprout it must absorb water and swell. Though the swelling of a seed is a necessary preliminary, it is not always followed by germination, for the absorption of water is a purely mechanical process and does not imply vitality in the seed. The entrance of water into the seed is dependent upon the structure of the seed coats. When these are hard and impervious, as is often the case in leguminous seeds and in nuts, water gains admission slowly and germination is retarded. In cereals and in most garden seeds the seed coats are easily penetrated by water, the seeds swell rapidly, and germination is prompt. Experiments have proved that seeds will absorb moisture and swell in a damp atmosphere, but that for germination, contact with water is necessary. An atmosphere saturated with water vapor is not sufficient to induce germination. Flaxseed kept in a saturated atmosphere for nine days, and seed of kohl-rabi kept under the same conditions for twenty-two days, did not germinate (Nobbe, Handbuch der Samenkunde). Too much water is equally injurious. As a general rule, seeds will not germinate well when immersed in water. It is necessary to have the seeds in contact with some medium from which they can obtain an abundant supply without allowing water to stand around them.

Light exerts a harmful influence upon germination. Experiments have shown that seeds placed under colored glass did not germinate as rapidly as those which were in complete darkness. Even more important than the exclusion of light is the free access of air and the escape of the noxious gases generated by germinating seeds. When germination has commenced, carbonic acid gas is given off, which must be allowed to escape, or growth will be checked.

SELECTING SAMPLES.

Selecting the sample to be tested is a matter of great importance. It must be a fair sample, including both good and bad seeds. If the quantity to be tested is considerable, small amounts should be taken from different parts of the mass. These small samples, thoroughly mixed, form the larger sample out of which the proper number of seeds is to be counted. In case the quantity of seed is small, say one-half pound of clover seed, pour the seed from the package into a pan, taking a small spoonful occasionally from the stream. From the quantity thus secured a sample for testing is taken. The number of seeds used in testing depends upon the size of the seed and upon the quantity at disposal.

If the sample is large enough, 100 seeds of the larger kinds and 200 to 400 of the smaller seeds are taken. The increased number is a check upon error in counting small seeds. In counting out the seeds a fair number of small and immature ones should be selected as well as the large and plump ones. There is reason to suspect that in some

tests only fine-looking seeds are used. These would, of course, give a higher percentage of germination than could be sustained by the entire sample. In selecting grass seeds for testing, care must be taken to use only such as contain a grain. In some kinds of grass seeds there are many empty glumes which it is difficult to distinguish from those containing a grain. A simple way to separate them is to wet the seed, spread it out on a plate of glass, and hold the plate up to the light. The empty chaff will appear translucent, while the good seed will be opaque.

KEEPING A RECORD.

Although for the results usually desired in home seed testing it is not absolutely necessary to keep a record, yet such a record, if well made, will be found to contain much valuable information. A few items will always need to be recorded, in any event, such as the date of beginning the test, the name of the variety, the number of seeds, and the number of germinated seeds removed from day to day. It is dangerous to trust anything to memory. Mistakes are sure to occur, and the test will then be useless.

LENGTH OF TIME REQUIRED.

The length of time a test should continue depends upon the seed. In the seed-control stations ten days has been accepted as the proper time for most seeds, but a few require a longer period, namely:

	Days.
Esparsette, serradella, beet-seed balls, rye grasses, timothy, carrots	14
Grasses, except meadow and rye grasses, and timothy	21
Meadow grasses (*Poa*), coniferæ (except white pine), birches, alders, acorns, beeches, and hornbeams	28
White pine and stone fruits	42

The seeds should be examined each day, and those that have germinated should be removed and the number recorded. A seed is considered as germinated as soon as the root breaks through the seed coats.

Under favorable conditions more than one-half of the seeds in a good sample will germinate in a much shorter time than that given above. The rapidity with which the seeds germinate is some indication of the vigor of the embryo, and determines the germinative energy.

The number of days in which more than one-half of the seeds in a good sample should germinate has been fixed as follows:

	Days.
Cereals, clovers, peas, vetches, flat peas, flax, dodder, poppy, cabbage, radish, spurry, chicory	3
Squashes and pumpkins, cucumbers, beans, spinach, lupine, buckwheat, burnet	4
Beet, timothy, serradella, bird's-foot clover, rye grasses, meadow foxtail, reed grass	5

	Days.
Redtop, hair grass, chervil, carrots, fennel, esparsette, sorghum	6
Spruce, fox-tail grass, sweet vernal grass, canary grass, *Deschampsia*, *Trisetum*, *Poa*, crested dog's tail, velvet grass, red and sheep's fescue	7
Fir, pines (except white pine), maple	10
White pine[1]	14

In nearly every test, especially of leguminous seeds, there will be some that remain hard. These can not be regarded as dead seeds, because their condition is due to the hardness of the seed coats. The number of such seeds should be recorded.

SPECIAL CARE NEEDED IN TESTING BEET-SEED BALLS.

In testing beet-seed balls special care is necessary in recording the number of germinated seeds. The balls must be left in the test

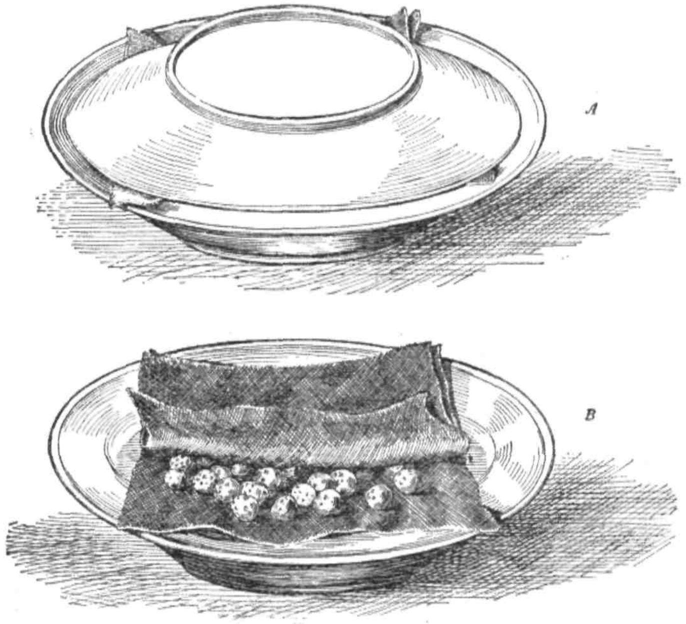

FIG. 23.—Simple germinating apparatus. *A*, closed; *B*, open.

during the entire period of fourteen days, but whenever a seed has sprouted it must be cut out with a sharp knife; or the root may be allowed to grow two or three days and then broken off and counted. The roots will either not grow out again, or, if they do, can not be mistaken for fresh ones. Either operation is very simple, and can be done by any one without the least trouble. The removal of the germinated seed or of the young roots is the only sure way of making an accurate test of the germination of beet-seed balls. One hundred seed balls should produce at least 150 seedlings.

[1] Yearbook, U. S. Department of Agriculture, 1894, p. 399.

APPARATUS.

The apparatus used for home seed testing should be as simple as is consistent with a reasonable degree of accuracy. Any method that complies with the conditions given above—a proper amount of heat, moisture, air, and the exclusion of light—will give good results. Fortunately, these conditions are so easily fulfilled that the most inexpensive apparatus will answer. Perhaps the simplest and at the same time the most satisfactory is the following:

Take two plates and place in one of them a folded cloth; wool or flannel is preferable, since it remains moist for a long time, but any cloth will do. The cloth should be free from dyes that will come out in water, since they may contain chemicals that would be injurious

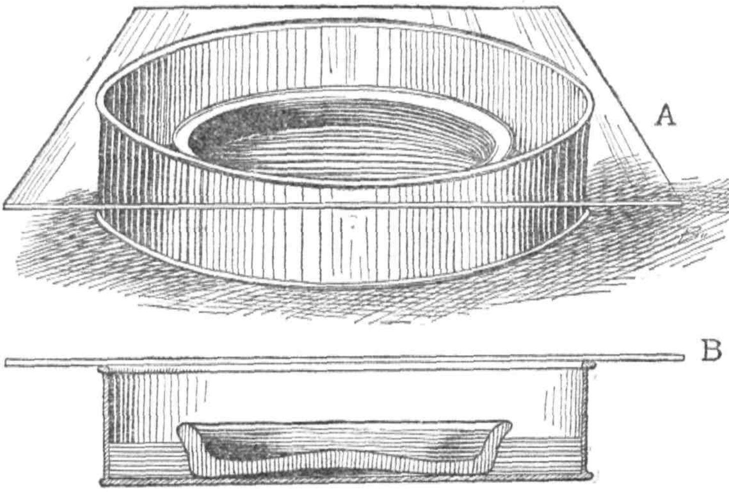

FIG. 24.—Homemade germinating apparatus. A, complete; B, section.

to the seed. Wet the cloth, pressing out the surplus water, leaving it very damp, but not soaked. Place the seeds between the folds of cloth, put in the number of the record, marked in pencil on a piece of paper, with date and number of seeds, and cover with the second plate, inverted. Plenty of air will get in between the plates, and the upper one will prevent too rapid evaporation of moisture. If the tests are to be made during the winter, keep the apparatus in the living room, as the heat of such a room will be sufficient for most seeds. During the night the seeds should be put in a warm place. Instead of the cloth, old newspapers, well soaked, can be used. These need to be moistened more frequently, however. (See fig. 23.)

Another apparatus that will give good results, especially for seeds not larger than wheat, is the one shown in fig. 24. Here the seeds are placed free on the bottom of a porous saucer and the latter put inside of a tin basin. The basin should have at least two coats of

mineral paint to prevent rusting. Water is poured into the basin up to about one-half the height of the saucer. The water will soak through the saucer and supply the seeds. For larger seeds this method is slow, since the seeds do not get water rapidly enough.[1]

A very simple apparatus is a glass or porcelain dish or tin pan with a little water in the bottom, and a handful of cotton batting, soaked, and placed in the dish. Put the seeds on the cotton and cover the dish with a plate of glass.

If it is desired to test a number of samples in the same apparatus, a convenient form is the following: Take a large dripping pan or an ordinary frying pan. Paint it to prevent rusting. Put four supports in the pan (inverted porous saucers are good) and place a tin or wire frame upon them, as shown in fig. 25. The seeds are laid between folds of blotting paper or cloth, which are then placed on the frame. A flap of paper or cloth hangs down into the water, which half fills the tray and keeps the folds moist.

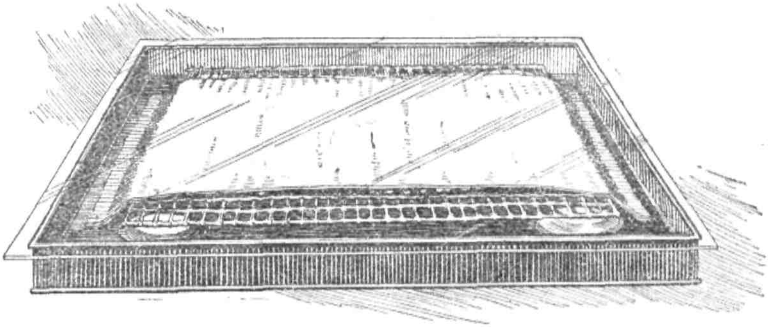

FIG. 25.—Apparatus for germinating several varieties at one time.

If glass can be had to put over the pan, evaporation will not be so rapid; otherwise the water will need replenishing frequently.

The tin or wire tray need not be expensive, and can be replaced by anything the operator may have. It is only necessary that a flap should dip into the water to provide moisture.

In testing seed some trouble will be experienced from the growth of mold. If the cloths and dishes are used many times, this trouble will become worse unless the spores of the fungi are killed. This can easily be done by boiling all cloths and washing the dishes in boiling water after each test.

In testing seeds it is necessary that there should be a standard of germination with which the germination of the sample can be compared. If the percentage of germination falls far below the standard, the seed is not fit for use, and its value decreases for every per cent

[1] An improvement on the above is described in the Yearbook of 1894, p. 405. Here folds of blotting paper or flannel cloth are placed in the porous saucer and the seeds laid between the folds.

of difference between its germination and that required by the standard.

The following table is offered provisionally, having been made up from original data and the most reliable outside sources. A great deal of experimenting will be necessary before a permanent table of germination standards is offered:

Table of germination standards.

Seed.	Percentage.	Seed.	Percentage.	Seed.	Percentage
VEGETABLE AND GRAIN SEEDS.		VEGETABLE AND GRAIN SEEDS—continued.		VEGETABLE AND GRAIN SEEDS—continued.	
Asparagus	90	Leek	85	Turnip	95
Beet	150	Lupin, yellow	90	Wheat	95
Brussels sprouts	95	Gherkin	92	GRASSES AND FORAGE PLANTS.	
Borecole	95	Melon, musk	92	Rape	95
Broccoli	85	Melon, water	92	Sorghum	90
Beans, bush	95	Mustard	95	Spurry	90
Beans, lima	95	Onion	85	Clover, red	90
Buckwheat	92	Okra	85	Clover, white	85
Cabbage	95	Oats	95	Clover, alsike	85
Carrot	85	Parsley	75	Clover, scarlet	90
Celery	65	Parsnip	75	Grass:	
Celeriac	65	Peas	98	Fowl meadow	75
Corn, field	92.5	Pepper	85	Johnson	75
Corn, sweet	92.5	Pumpkin	92	Kentucky blue	50
Cucumber	92	Radish	95	Meadow fescue	80
Collards	95	Rhubarb	85	Orchard	80
Cauliflower	85	Salsify	83	Texas blue	50
Chicory	85	Spinach	89	Timothy	90
Cress	90	Squash, winter	92	Millet:	
Eggplant	85	Squash, summer	92	Common	85
Endive	94	Sunflower	90	Pearl	85
Kohl-rabi	90	Tomato	90		
Lettuce	90	Tobacco	88		

Nothing has been said in this article about testing seeds for purity. This is an important matter, but could not be properly treated in a few pages. Garden and flower seeds ought always to be nearly pure, but those of grasses and forage plants, especially clovers, frequently contain a considerable amount of foreign matter. The seeds of harmful weeds are often found in quantity in clover seed. Farmers should be on their guard against impure seeds.

OIL-PRODUCING SEEDS.

By Gilbert H. Hicks,
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GENERAL REMARKS.

There are over 200 species of plants whose seeds are used in making oil for illumination, medicine, food, soap, and lubricating machinery. A large proportion of these plants are natives of tropical regions, many of which will not thrive in colder climates. On the other hand, there are many plants which could be profitably grown in the United States for the oil contained in their seeds. A few such plants are now cultivated in this country, principally, however, for other purposes than the use of their seeds for oil, as in the well-known cases of cotton, peanuts, etc.

The object of this article is to collate from reliable sources information concerning some plants which now are or which might be grown with profit for oil, thus developing a new line of agricultural activity which may in many cases prove profitable.

Oils are divided into three classes: Fatty oils, mineral oils (such as kerosene, benzine, etc.), and volatile, or essential, oils (oil of turpentine, camphor, etc.). Oils of the first group are subdivided into those of vegetable and those of animal origin. Of the former, seeds furnish the main supply, although no part of the plant seems to be entirely wanting in fat. That found in the organs of vegetation, however, is more wax-like. The oily matter in seeds is stored up as food to be used by the young plant during the early stages of germination, before it is able to absorb food materials for itself from the earth and air. All seeds store up oil or starch for this purpose. The amount of fat in plants is said to be in nearly an inverse ratio to the amount of starch and sugar which they contain, ranging from 67 per cent in the brazil nut to only 1 per cent in barley.

Oil is obtained from seeds by first crushing and then pressing them in cloth bags, or by boiling them in water and skimming off the oil which rises to the surface, or by using some chemical solvent, such as carbon disulphide, which extracts the oil. The first method is that generally employed, although the chemical process is coming into use to a large extent. Seeds are either pressed cold in mills constructed especially for that purpose, or heat is used to coagulate any albumen present and to render the oil more liquid. In many

instances both cold and warm pressure are used, but in the case of the best medicinal or table oils no heat is employed. The method of using solvents commonly yields a greater amount of oil than does pressure, but is open to objections. The crude oils obtained by pressure or extraction are refined by filtering and the use of chemicals.

The residue of the seeds after the oil is extracted is called "oil cake," and is often of great value as a stock food or fertilizer. It is composed of the woody fiber and mineral matter which the seed contained, a small per cent of unextracted oil, and, of more value than all else, the proteid or nitrogenous constituents of the seed. This gives it especial value as food, while the high per cent of phosphoric acid and potash in addition to nitrogen makes it a most valuable fertilizer. The exportation of cotton-seed cake from the United States in 1894 was over 600,000,000 pounds, worth over $7,000,000, while that of flaxseed amounted to nearly 128,000,000 pounds, valued at $1,700,000. Three-fourths of this material went to Great Britain.

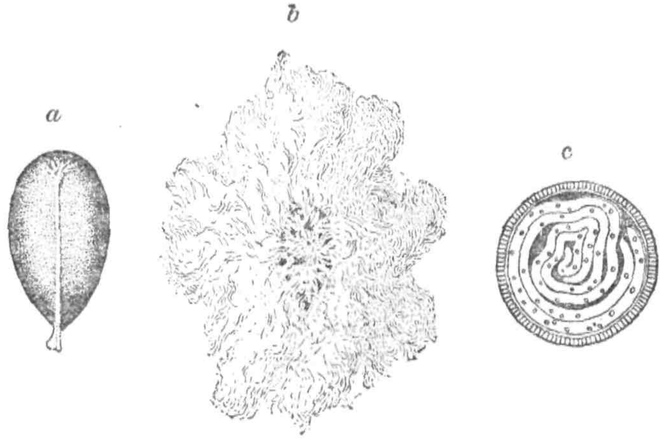

FIG. 26.—Cotton (*Gossypium barbadense*). *a*, seed, delinted, magnified 3 times; *b*, seed with coma attached; *c*, transverse section, showing the crumpled embryo filling the seed coats.

COTTON-SEED OIL.[1]

The cotton plant (various species of *Gossypium*) has been cultivated from time immemorial, principally for the fiber attached to the seeds. It occurs in Asia, Africa, and tropical America, but is also grown in some parts of Europe, and, as is well known, cotton fiber forms one of the principal products of the Southern States of this country.

The black seeds (fig. 26) are almost hidden by a tuft of white fiber which covers their surface. They are irregularly egg-shaped, from 6 to 9 mm.[2] long and 4 to 5 mm. broad. The thick seed coat is filled

[1] See Farmers' Bulletin No. 36, U. S. Department of Agriculture.

[2] For metric system, see Appendix. Consult index.

with the coiled embryo, which is sprinkled with brownish resin glands easily seen with the naked eye. The cells composing the embryo are filled with drops of fat and other matter. The seeds contain from 15 to 20 per cent of oil, which for hundreds of years was wasted, for the seeds proper were thrown away after stripping off the fiber. It is only within the present century that they were considered of any value except for planting.

In 1826 a Virginian was led to experiment with cotton seed. He made a small machine with which he was able to express a dark-red oil that gave a fair light when burned in an ordinary lamp. In the same year, it is reported, an oil mill was constructed at Columbia, S. C., which expressed a good quality of oil from cotton seed. From this beginning there has arisen a great industry, and although cotton is still grown mainly for the fiber, the seeds are now carefully saved for the oil. Great difficulties were experienced at first in extracting all of the oil contained in the seeds, since in the process of delinting a considerable amount of fiber remained attached to the seed coat, and this greedily absorbed a large per cent of the oil. Machines have been invented, however, for removing almost all the lint as well as the hulls themselves. In Europe the seeds are first pressed cold and then warm, but in America warm pressure is generally used from the first. The crude oil is a thick fluid, of a dirty brown color. By refining it becomes straw colored or nearly colorless.

Estimating 2 pounds of seed for every pound of ginned cotton, nearly 4,000,000 tons of seed were produced in the United States in 1894–95. Deducting about one-third of this, required for sowing, there would remain over 2,500,000 tons of seed. Of this amount about 1,500,000 tons were worked at the oil mills, each ton producing 45 gallons of crude cotton-seed oil and 800 pounds of cotton-seed cake. This estimate gives the immense total of 60,000,000 gallons of oil and 600,000 tons of oil cake produced in the United States in a single year. At 30 cents a gallon, this crude oil was worth $18,000,000, while the oil cake exceeds $12,000,000 in value. Of this annual production of oil about 9,000,000 gallons are used in making "compound lard," while the rest is either exported or mixed with drying oils or used in the manufacture of soap. Cotton-seed oil is also largely used for adulterating olive, lard, sperm, and other oils.

During the last two years the exportations of cotton-seed oil from this country have been as follows: In 1892–93, 9,462,074 gallons, valued at $3,927,556; in 1893–94, 14,953,309 gallons, valued at $6,008,405. The principal European country extracting oil from cotton seed is England, the seed being obtained mainly from Egypt, from which country the United Kingdom imported, in 1894, 314,756 tons.

Cotton-seed meal makes an excellent fertilizer. In exchanging with farmers, oil mills give 1 ton of meal for $2\frac{1}{4}$ to $2\frac{1}{2}$ tons of seed. The hulls are used for fuel, paper, or feeding like hay. In Russia oil cake is used to some extent for stock food. In America the cake

could produce as good seed, both for sowing and oil, as any part of Europe.

The method of cultivation of flax is somewhat different when it is raised for seed from that when fiber is desired. In the former case it is a common American practice to sow 30 to 45 pounds of seed per acre early in the spring upon turned sod of virgin soil without special fertilizing. In Europe the land is cultivated at least 8 inches deep and well fertilized with stable or liquid manure or commercial fertilizers. Nothing better can be used for this purpose than flaxseed cake.

The seeds should be sown with a drill, and plenty of room allowed for sun exposure. When the young plants are a couple of inches high, they should be carefully weeded, and thinned if necessary. Flax is harvested for seed when two-thirds or more of the stalks have turned yellow and the seed begins to loosen in the capsules. The harvesting should be done when the plants are free from moisture. Before thrashing, the seed is left for some time in the capsules that it may become thoroughly ripe. Various methods are employed for thrashing out the seed. If the seed only is desired, an ordinary thrashing machine is sufficient, but special machines are necessary when both fiber and seed are saved. From 8 to 20 bushels of flaxseed are produced per acre, the latter amount being considered a large crop, secured only on the richest land with the best cultivation. The seed brings about $1 a bushel, which, added to the value of the straw when grown for fiber, makes flax a very profitable crop.

For further information concerning flax the reader is referred to the bulletins of the Department on fiber investigations.

CASTOR-OIL BEAN.

Castor oil is obtained from the seed of the castor bean (*Ricinus communis*), a member of the family Euphorbiaceæ, which furnishes over 20 species of oil-producing plants, most of them indigenous to tropical countries. The castor bean is a native of India, but is cultivated in many parts of the globe. In Persia it furnishes the chief illuminating oil. The seed is crushed along with raw cotton wool until the oil is expressed. The cotton thus soaked is rolled up into the form of tapers, which furnish the common household illuminant.

The seeds of the common large-seeded variety (fig. 28) are oval, smooth, and shining, of a gray ground color, irregularly marked with brown. They are 10 to 20 mm. long, 6 to 10 mm. broad, and about 6 mm. thick, slightly pointed at the upper end, which is provided with a whitish fleshy excrescence (caruncle). They are contained in a three-lobed, spiny capsule, each lobe holding one seed. When ripe, the capsules split from the bottom upward, throwing the seeds to a considerable distance. The kernel is composed of two thick, fleshy, white lobes of endosperm, which inclose a thin, leaf-like embryo. A small-seeded form is used for medicinal purposes, while the large-

seeded variety furnishes an oil used for lighting and in the making of soaps.

Castor-oil seed is inodorous, and has at first a sweetish taste, becoming sharp afterwards. The shell amounts to 20 to 24 per cent of the entire seed. The kernels contain from 50 to 60 per cent of oil. It is viscid, of a pale yellow color, with a disagreeable smell and taste. Castor oil is very readily soluble in alcohol, which, with its density (the greatest of the vegetable oils), renders adulteration easy of detection. It is frequently adulterated with poppy-seed oil, to which a few drops of croton or jatropha oil is added.

The best kinds of castor oil come from Italy, Calcutta, and Madras, where the seed is deprived of its shell before being pressed. This is done by women who pound the seed with wooden hammers. In America and some other countries the shells are removed by special machinery. The shelled seed yields from 50 to 60 per cent of oil, which is more than that yielded by almost any other plant. The oil is obtained by pressing twice cold and a third time warm, by boiling with water, and extraction by the agency of alcohol. It soon becomes rancid upon exposure to the air. The oil is extensively used in medicine as a purgative, also in pomades, for illumination, soap making, for lubricating machinery, in veterinary practice, and, in China, as a condiment. The uses to which castor oil is devoted are constantly increasing, and a very large amount is consumed.

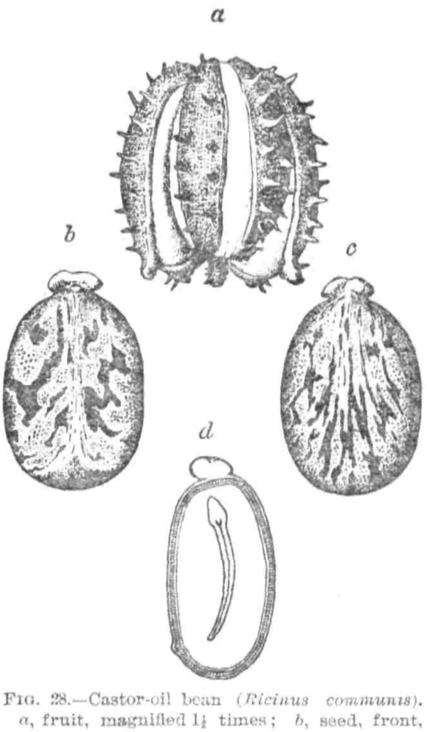

FIG. 28.—Castor-oil bean (*Ricinus communis*). *a*, fruit, magnified 1½ times; *b*, seed, front, magnified 2½ times; *c*, back; *d*, longitudinal section.

In India castor oil is considered the best lamp oil, giving a white light, vying in brilliancy with electricity, far superior to petroleum and other illuminating oils. It burns slowly, without danger, and gives off scarcely any soot. The railway trains of India are lighted almost entirely with castor oil, and an excellent gas made from the cake is being introduced into the railway stations. The principal shipments are from India and Italy. The former country in 1894–95 exported 2,679,236 gallons. American oil is considered superior to that from India, while the Italian is said to be the best of all.

In Florida and other warm countries the castor bean is a perennial plant, growing from 15 to 30 feet high and as large around as a man's body. In colder climates it behaves as an annual, dying down upon the approach of winter. The seeds are produced in great abundance, and their tendency to scatter when ripe renders the plant a great pest where it grows wild.

The castor bean thrives in the sandiest soil, and its culture is very simple. The seeds germinate with difficulty, owing to their thick and impervious coat; hence nearly boiling water should be poured over them before sowing, and they should remain in this for about twenty-four hours, the temperature of the water in the meantime gradually lowering to that of the atmosphere. They should be planted in hills, 2 inches deep, 8 or 10 seeds to a hill, and afterwards thinned out to 1, or at most 2, plants per hill. The rows are 5 or 6 feet apart, with the hills 2 or 3 feet distant. Between every sixth and seventh row should be left a space of about 8 feet, to permit the passage of a horse and wagon when the beans are harvested. In the South, where the castor bean grows more vigorously, the hills may be 6 or 7 feet apart. *Planting should take place as early in the spring as possible*, making allowance for frosts, to which the Ricinus is very susceptible. The cutworm, too, is sometimes a serious obstacle to its cultivation. The land should be kept free from weeds and the crop grown much the same as corn or beans, and on very similar soil.

In harvesting, the fruiting branches should be cut off as soon as the pods begin to pop open, which is in July in the South. This process must be repeated at least once or twice a week, as fast as the seeds ripen. The fruits are then spread out to dry, either on the floor of a granary or other close room or in a "dry yard" built near the castor-bean fields. This yard is made by cutting away the sod, rolling the ground hard, and building a tight board fence around it to prevent loss from the beans scattering. It is better to make a tight board floor for the dry yard, which should be in a sunny place, sloping to the south. The spikes must be turned over occasionally and kept protected from moisture. After the seeds have popped out they are cleaned from the shells with a common fanning mill.

Ricinus seeds should show at least 95 per cent germination and 98 per cent purity. The seeds of commerce are sometimes mixed with those of *Jatropha curcas*, a tropical plant belonging to the same family.

Castor-oil plants have been cultivated to some extent in the United States for over twenty years. According to Simmonds, Kansas, in 1895, produced 361,385 bushels of seed from 24,145 acres, nearly 15 bushels per acre, the seed weighing 46 pounds to the bushel. In Iowa the yield is 15 to 25 bushels per acre, while in the Southern States from 35 to 40 bushels, or more, could easily be raised. The seed sells at about $1.25 per bushel. The pomace is considered

valuable for fertilizing purposes. This plant would do well on the light, sandy soil of the Gulf States, and might be made a profitable industry, utilizing land that is now practically valueless.

EUROPEAN SPURGE.

Spurge oil is furnished by *Euphorbia lathyris*, a herbaceous plant indigenous to southern Europe, but found in various parts of the United States, where it is usually an escape from gardens. Charles the Great recommended it to his monks for cultivation in their cloister gardens.

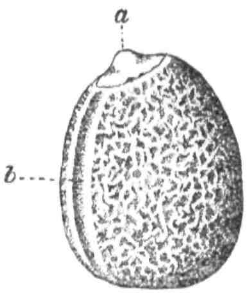

FIG. 29.—European spurge (*Euphorbia lathyris*). *a*, caruncle; *b*, raphe. Magnified 5 times.

The seeds (fig. 29) are roundish oblong, with blunt ends, reddish brown, having a roughish surface, with a prominent furrow (raphe) extending the entire length of the ventral side. They are 3 to 5 mm. long by 1.5 to 3.5 mm. wide and 4 mm. thick, with a small caruncle at the upper end like that of the castor-oil bean, to which family the plant belongs. The seeds contain 35 to 45 per cent of a very fluid, light yellow to brownish oil, which is at first mild, but afterwards sharp and odorous.

The oil is used as a rubefacient and vesicant; also as a purgative, in doses of 10 to 20 drops. In Europe it is employed to some extent as a luminant and in the manufacture of soaps. It differs from croton and castor oils by its utter insolubility in alcohol. Notwithstanding its valuable properties, spurge oil is employed but little, on account of its high price. There are many species of spurge growing wild throughout the United States, although the seeds of most of them are too small to be of much economic value. *Euphorbia lathyris* would grow readily in most parts of the country, and its cultivation might be worth a trial.

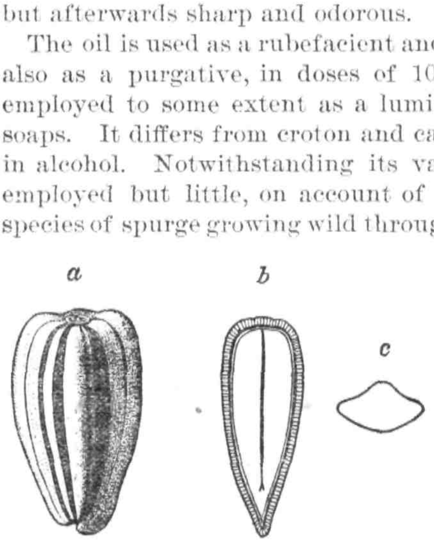

FIG. 30.—Sunflower (*Helianthus annuus*). *a*, akene, magnified 2½ times; *b*, longitudinal section; *c*, transverse section in outline.

SUNFLOWER.

The common sunflower (*Helianthus annuus*) is an annual, 5 to 15 feet high, and indigenous to America. In 1569 it was introduced into Europe, and is now extensively cultivated there, particularly in Russia, where it has been grown for over fifty years, principally for the oil contained in its seed-like fruits (akenes). It grows wild throughout the United States. The akenes (fig. 30) vary a good deal in size, some from southern California being but 5 mm. long and one-half as

wide, while in cultivation they average from 8 to 10 mm. long by 6 to 8 mm. wide and 3 to 4 mm. thick. They are obversely egg-shaped, compressed, usually of a gray color striped with black, and in some cases entirely white or black. The gray and striped seeds are preferred by some growers, the smaller ones being said to contain the most oil.

The seeds, after the shells are removed, contain 34 per cent of oil, of which 28 to 30 per cent is extracted by cold and warm pressure. Sunflower oil is clear, light yellow, nearly odorless, and of a peculiar, pleasant and mild taste. This oil is said to be superior to both almond and olive oil for table purposes, and is used in making soap, candles, and for lighting. The residue, after extracting the oil, is made into oil cake for feeding cattle. The export of this cake forms one of the principal industries of Russia.

In Russia the larger seeds are sold in immense quantities to the common people, who eat them much as we do peanuts. The stalks furnish a valuable potash fertilizer, while the green leaves are dried, pulverized, and mixed with meal as food for cows. Sheep, pigs, and especially poultry, fatten rapidly upon the seeds, preferring them to other kinds of food. The stalk is said to produce an excellent fiber by treating it the same as flax. It is said, also, that much of the Chinese silk goods contains sunflower fiber. Five or six cords of stalks are produced per acre, which are sometimes used for fuel, while the flowers furnish a yellow dye.

The foregoing remarks apply to the culture and the use of the sunflower in Europe. In this country attempts at its culture have been made by a few experiment stations and private individuals. According to a newspaper report, a farmer in South Dakota planted, in 1895, 100 acres to Russian sunflowers. The main drawbacks thus far to sunflower raising in America are the lack of machinery and the want of a good home market for the oil. It is likely, however, that these difficulties will be ultimately overcome.

In Europe old mortar broken up is said to make an excellent fertilizer for sunflowers. Fresh manure, especially horse manure, causes an undue development of the stalks and leaves at the expense of the seeds. It is recommended that old manure be applied to the field in the fall, the seed being sown as early as possible in the following spring.

The seeds should be planted about 1 inch deep, 6 inches apart, 18 inches between the rows. When the plants are 8 or 10 inches high, thin them out to 30 inches apart and hill them slightly. Keep them entirely free from weeds. When about 3 feet high, the runners should be cut off, leaving one main stem with four or five flower heads. No further care is needed until harvesting.

The soil should be rich, dark mold, with as little shade as possible, since the sunflower, as its name indicates, requires plenty of sun.

About 6 pounds of seed per acre is recommended, and it may be sown in drills.

The heads must be harvested promptly as soon as ripe, as birds are very fond of the seeds. If the acreage is small, the heads may be taken off one by one as fast as they ripen. Care must be exercised to dry them as rapidly as possible to prevent molding. In Europe the average yield per acre is 2,000 pounds of seed, giving 250 pounds of oil. In America the seed sells from 1½ to 2½ cents per pound.

In thrashing the heads it is best to pile them in a row on the barn floor, placing the seeds uppermost. Continue in this manner until the pile is about 2 feet high, placing the last row with the seeds down to prevent breaking them with the flail, this being used in thrashing. The seeds are then thoroughly dried in the sun and run through a cleaning mill. They are next separated by means of screens into two sizes—one large, the other small.

Sunflower seed may be purchased from any prominent seedsman. It should show a germinating per cent of 90 and a purity per cent of 99. The price of labor in Russia where sunflower raising is such an industry is so much smaller than in this country that the profit in the business for American farmers is a somewhat uncertain factor at present.

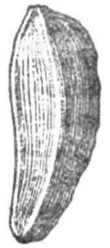

FIG. 31.—Madia (*Madia sativa*). Akene magnified 5 times.

MADIA SATIVA.

This plant, belonging to the sunflower family, is a native of Chile, where it has been cultivated a long time for oil. It is an annual, growing from 1 to 3 feet high, with a large mass of sticky, ill-smelling foliage and yellow flowers. The akenes (fig. 31) are 6 to 7 mm. long, 2 to 2.5 mm. wide, and 1 to 1.5 mm. thick, slightly bow shaped, broadest at the upper end, gray in color, the surface being ridged with fine, longitudinal lines. The seeds contain about 32 per cent of a rich oil, which is used for food, making soap, and illumination, and is said to be as good for cooking purposes as olive oil, which it supersedes in some countries. The fact that it does not readily congeal makes madia oil valuable for lubricating machinery. Madia has been cultivated to some extent in France and Germany and grows wild very abundantly in California.

It flourishes on almost any kind of soil, and as it requires but three months to ripen may be sown late in the spring if desired. The cultivation of madia is very simple, although, as in the case of other crops, it responds to good soil and tillage. In France it is sown broadcast from the middle of April to the middle of May on well-prepared mellow soil, about 20 pounds of seed per acre. The seed comes up in ten to twelve days, and as soon as the plants have made a stand they are thinned out. At the first hoeing they are again thinned to 1 foot

apart. The crop is harvested within ninety to one hundred days after sowing.

Harvesting should take place as soon as the seeds are well "set," without waiting for them to become thoroughly ripe, as they shell out easily; moreover, they finish ripening after the plants are cut. Harvesting is done in France with a sickle. It is claimed that if properly cultivated and gathered madia will yield from 1,200 to 1,400 pounds of seed per acre, making over 20 gallons of oil. The plants should be thoroughly dried before thrashing.

Madia could be successfully grown in California and other sections of the United States. The principal drawbacks are the disagreeable odor exhaled by the flowers, the greasy nature of the foliage, and the irregular ripening of the seeds.

NIGER SEED.

Niger-seed oil is made from *Guizotia oleifera*, another member of the sunflower family and a native of Abyssinia. It is an annual, furnishing the common lamp oil of upper India, where it is cultivated. The akenes are similar to those of madia, but smaller and darker. They are used in this country to some extent as bird food. They yield 35 to 40 per cent of a brownish oil, which becomes pale yellow after refining. It has a slightly aromatic odor resembling thyme. The cold-pressure oil is used for food, and that obtained by warm pressure for making soap, but it can not be used alone for this purpose, since it renders soap brittle.

In India the seed is sown in July or August, after the rainy season, and is treated like a wheat crop, no weeding or manuring being required. It yields about 2 bushels per acre, and is exported to London and Hamburg principally. This plant could undoubtedly be successfully cultivated in the warmer portions of the United States.

PEANUT.[1]

The earthnut, groundnut, goober, pindar, or peanut (*Arachis hypogæa*), as it is variously called, is a low, somewhat creeping annual belonging to the bean family. It is a native of the tropics, but has been for a long time cultivated very extensively in Africa, India, the West Indies, and warmer portions of America. Only the lowest flowers bear fruit, and after blooming these flowers lengthen their stems, which penetrate the ground several inches, where the fruit ripens.

The fruit (fig. 32) is 2 to 3 cm. long and 1 to 1.5 cm. thick, with a furrowed, yellowish pod, which contains from 1 to 4 seeds, 1 or 2 being the common number. In addition to their general use for food

[1] The peanut is more fully treated of in Farmers' Bulletin No. 25, U. S. Department of Agriculture.

and confectionery, the seeds furnish 38 to 50 per cent of oil. The first cold pressing yields an almost colorless oil, of pleasant taste and smell, which is excellent for table use. After the first pressing the seeds are sprinkled with water and pressed again, cold, to obtain the oil, which is also used to some extent for food purposes, but mostly for illumination. The third oil is extracted by warm pressure; and is in great demand for making various kinds of soaps. The cake is considered an excellent food for stock. The peanuts grown in tropical countries are said to yield a much greater per cent of oil than those raised in temperate regions.

In the United States peanuts are usually planted after corn, 2 bushels of seed being used to the acre. Planting takes place as soon as all danger from frosts is past. A warm, sandy loam containing some lime is the best soil for peanuts. The crop is from 80 to 120 bushels an acre. The oil is chiefly extracted at Marseilles, France, which annually imports 137,000,000 pounds of peanuts. In this country peanuts are principally used for eating, 3,250,000 bushels being

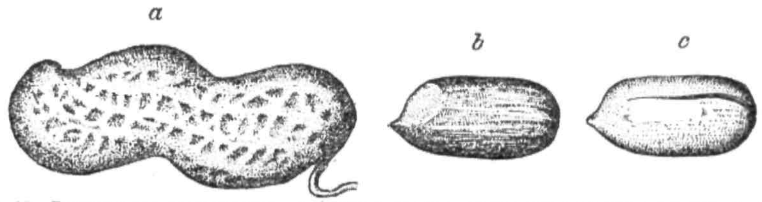

FIG. 32.—Peanut (*Arachis hypogæa*). *a*, fruit; *b*, seed; *c*, same with coat removed, showing the fleshy cotyledons. All magnified 1¼ times.

consumed annually for that purpose. In other countries they are not esteemed so highly for food, hence nearly all the foreign product is used for oil. At present the conditions in the United States are not favorable for making oil from peanuts, although it has lately been attempted on a small scale. It is quite likely, however, that peanut-oil manufacture will become an important industry in America in the future.

SESAME.

The oil of benne, or sesame oil, as it is more frequently called, comes from the seeds of *Sesamum indicum* and *S. orientale*, two almost, if not quite, identical plants belonging to the Pedaliaceæ. They are indigenous to the East Indies, but are extensively cultivated in Japan and other subtropical countries. Within a comparatively few years their culture has been undertaken by Germany, France, Austria, and England. *Sesamum orientale* has been cultivated in Asia since the earliest times. The Babylonians and ancient Egyptians used the seeds for food, and the Egyptian women prepared a cosmetic from them.

The plants are hairy, sticky annuals, about 3 feet high, and produce an abundance of small, flat, pear-shaped seeds (fig. 33), those of

Sesamum indicum being yellowish white, while the seeds of *S. orientale* are black. Sesame seeds are very rich in oil, yielding from 50 to 56 per cent in the black-seeded varieties, and 47 to 52 per cent in the white-seeded varieties. The former are also said by some to produce a better oil than the latter, while others claim the reverse is true. The seeds are also used in confectionery and for making soups.

The oil is clear, of a pale straw color, sweet, and nearly tasteless. It is obtained by three pressures, twice cold and the last time warm. The first pressure gives the best oil for food purposes. Sesame oil is frequently used to adulterate almond oil. It is also used for making soaps, for illumination, in perfumery manufacture, and for the toilet. The seeds of commerce come chiefly from the East Indies and the Levant, the oil being pressed at Marseilles and Trieste. The best seed is shipped from Jappa to Marseilles, where the oil brings the highest price of any of the many kinds in the Marseilles market. The leaves of the sesame plant are considered of medicinal value, from the mucilaginous matter which they contain.

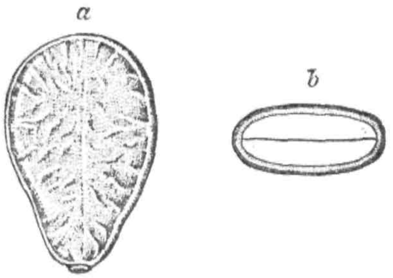

FIG. 33.—Sesame (*Sesamum indicum*). *a*, seed, magnified 10 times; *b*, transverse section.

Sesame ripens its seeds in most of the Middle States, and might be profitably cultivated in the South. The negroes near Charleston, S. C., are said to have grown sesame in a small way for two hundred years. They plant it in April and harvest the seeds early in October. The seed used for planting should show a purity of 98 per cent and germination of 90 per cent.

HEMP.

Hempseed oil comes from an annual plant of the nettle family (*Cannabis sativa*), which is indigenous in central Asia and the East Indies. It is cultivated in India, Persia, China, North America, Germany, and, more than anywhere else, in Russia. It grows from 4 to 8 feet high in waste and cultivated ground. The odor of the fresh leaves sometimes produces headaches, while the celebrated narcotic, *hashish*, is prepared from a gelatinous resin contained in the leaves and stems. The latter also furnish the well-known fiber used for cloth and cordage.

The male and female flowers are borne on different plants. The nut-like fruits (fig. 34), commonly called seeds, are used in great quantities as bird food. They are nearly egg-shaped in outline, flattened at the margins. Color, dark gray, with fine, net-like, whitish markings on the smooth and shiny surface. Each fruit is completely filled with the seed proper, which is of the same shape and about 4 mm.

long by 3 mm. wide and 2 to 3 mm. thick. The seeds contain no endosperm, but are filled with a whitish embryo which yields 30 to 35 per cent of a peculiar-smelling, mild-tasting oil, greenish yellow when freshly pressed, becoming brownish yellow with age. Hempseed oil is used to a considerable extent in the preparation of paints and varnishes, although it does not dry as readily as linseed oil. In Europe it enters largely into the composition of soft soaps. Sometimes it is used in the Old World as an illuminant and, rarely, for food.

Hemp will thrive in most parts of the United States, and is said to produce from 20 to 40 bushels of seed to the acre, worth about $2.50 per 100 pounds. With extra good care and soil the yield may reach 50 to 60 bushels. The seed should be planted in drills, early in April in the South, two weeks later in the North. The young plants are thinned out when a foot high, and must be kept free from weeds. The male plants should be pulled as soon as they have shed their pollen, so as to allow the seed-producing plants plenty of room and all of the available soil food.

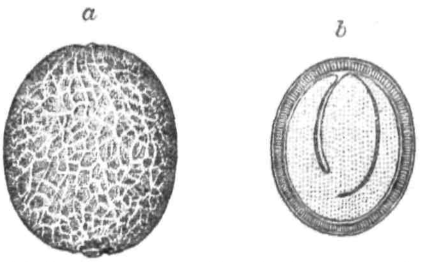

FIG. 34.—Hemp (*Cannabis sativa*). *a*, fruit; *b*, transverse section of seed. Magnified 6 times.

Hemp should be harvested promptly as soon as the seed begins to drop, which always takes place after a sharp frost, if not before. The seeds scatter easily; hence hemp should be cut early in the morning when the dew is on, and great care exercised to prevent waste. When cut, hemp should be set up in loose shocks to dry, a sheet being placed under each one, and some protection afforded from birds, as they are fonder of this seed than almost any other. Drying is completed by spreading the plants out on a tight barn floor, where they are thrashed by hand.

Hempseed, nothwithstanding its oily content, loses its germinative power quickly, usually by the end of one year; hence only fresh seed should be sown. Neither cracked nor dull-looking seed will germinate well. Hemp culture in America is mostly confined to Kentucky and Missouri, principally the former State. The value of hemp for fiber, birdseed, and oil would seem to make its cultivation a very profitable one.

RAPE.

Rapeseed, or colza, oil is obtained from the seeds of different varieties of the genus *Brassica*, rape (*Brassica napus*) in particular. In Europe the term rapeseed oil is sometimes applied to the product of rape alone, colza being restricted to the oil obtained from the ruta-baga, or Swedish turnip (*B. campestris*), while "Rübsen" oil is furnished by the common turnip (*B. rapa*). There is great confusion among authors in the use both of the common names of

the oils and the scientific names of the varieties of Brassica which produce them.

Since the characteristics of the different varieties of rapeseed oil, as well as the methods of culture of the plants themselves, are practically the same, we shall include them all under the head of rape.

According to Blomeyer, rape originated on the coasts of Holland and England. It has been cultivated extensively in Europe since the middle of the sixteenth century. In France rape constitutes seven-tenths of the acreage of oil seeds in cultivation, though this has decreased somewhat in recent years, owing to the more extensive use of mineral oils. In Germany there were 445,000 acres planted to the different varieties of Brassica in 1882, the value of the crop of rapeseed being over $10,000,000. Besides this, large amounts of rapeseed were imported, so that the value of rapeseed oil from Germany alone was $12,000,000 to $14,000,000, while in addition over $4,000,000 worth of rapeseed oil cake was produced. The total consumption of rape and colza oil in Europe is estimated at nearly 330,000,000 pounds per annum, valued at over $43,000,000. India annually exports from 2,500,000 to 4,000,000 hundred weight of rapeseed. A large part of this naturally goes to Great Britain, which imports about 880,000 pounds per year.

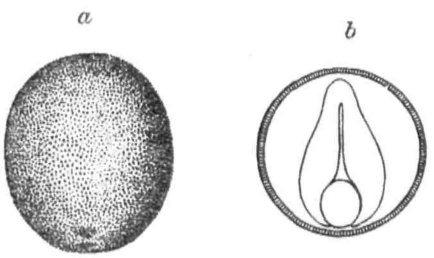

FIG. 35.—Rape (*Brassica napus*). *a*, seed; *b*, transverse section. Magnified 14 times.

The seeds of all the varieties of Brassica are spherical and not easily distinguishable from one another. Those of *B. napus* (fig. 35) are mostly bluish-black, *B. campestris* reddish-brown, *B. rapa* almost black. As a rule the seeds of *B. campestris* are somewhat larger than those of the other varieties, whose seeds average about 2 mm. in diameter. Brassica seeds are more or less pitted when seen under a lens. The seeds of rape contain from 33 to 43 per cent of oil, which when crude is a dark yellow brown and used for lubricating. Refined and freed from albumen and mucilage the oil becomes bright yellow. Rape oil is extensively used for lamps, lubricating machinery, and for adulterating both almond and olive oils. It is frequently adulterated with poppy seed, camelina, flaxseed, mustard, whale and fish oils, and with tallow. The refuse cake is a well-known and valuable cattle food.

Brassica campestris (colza) is said to yield one-third more oil than rape. Both rape and colza thrive best on rich, deep soil, especially after barley, wheat, and clover. The soil must be well drained. In a very light or very stiff soil heavy manuring is required, rapeseed cake being excellent for this purpose. Rich liquid manure, such as night soil mixed with water and drainings from barnyards, produces

extremely luxuriant plants. Under such conditions in Germany rape sometimes grows 6 feet high, yielding 1,200 to 1,500 pods to each plant, with 40 to 50 seeds in a pod. But such crops as this require the utmost fertility and care. No plant responds more noticeably to manuring and cultivation than rape, the difference often being more than 50 per cent over a neglected crop.

The different varieties of rape fall under two heads, summer rape and winter rape. *The former comes from seed sown early in the* spring and maturing in the same season, the plant being an annual. Winter rape is a biennial, or, more properly, a winter annual, and is considered a better oil plant. In Germany winter rape ripens in three hundred to three hundred and fifty days; summer rape in one hundred and forty to one hundred and eighty days. Summer rape is said to be a more uncertain crop than winter rape, being better adapted to a light soil. The yield is 33 to 50 per cent less than from winter rape. Rape will not withstand severe winters well unless covered with snow; hence, although bottom lands are considered excellent for summer varieties, they are not recommended for winter rape on account of their liability to frosts.

When planted for seed purposes, rape should be sown with a drill or a seeding machine. The seed should show a germinating per cent of 95 and a purity per cent of 99. In Germany different methods are used for sowing rape. In some cases it is drilled in rows 1½ to 2 feet apart, with the seed 4 to 5 inches apart in the row. Four to 7 pounds of seed is used per acre, winter rape being sown the last of July or before the middle of August, summer rape in May or as soon as danger of spring frosts is past. The land should be prepared thoroughly, and it is recommended that the seed be put in the fresh furrow the same day the land is worked. Sow one-half to 1 inch deep, rolling or dragging the land afterwards. About the middle of September the ground is cultivated, and in October hilled once or twice with a hill plow. If seeded too thick, it must be thinned as soon as the seedlings are well established in the soil, and again in the spring.

Another common practice in cultivating rape for seed is to sow in large beds and afterwards transplant. The seed bed may be prepared by digging trenches in well-manured, loamy soil. As soon as the plants have five or six leaves they are thinned to 4 or 5 inches apart. One acre of seed bed will furnish enough plants for 10 acres or more in the field. As in the other method, the seed is not sown until July or August, to prevent the plants from running to seed the same year.

Transplanting takes place in September or October, great care being exercised not to injure the roots. The plants should be carefully lifted out of the soil with a fork, the earth still clinging to their roots, and placed in flat baskets, tops upward. In planting, the holes should be made with a large dibble or narrow hoe. The earth is

drawn up to the plant with another hoe, and as the holes are filled the planter firms the earth with his foot as he walks along. Two men with hoes and one boy to insert the plants would cover a large space in a short time. In the spring the weeds must be carefully cleaned out, and if the ground has been oversoaked during the winter, the rape should be hilled a second time.

Rape ripens its seed very unevenly, the lower pods beginning to burst before those at the top are filled. The crop should be harvested at the end of June or the 1st of July, when the pods begin to turn brown and the plants are fully mature, so as to prevent a waste of the seed, which rattles out easily. It should be cut in the morning when the dew is on. In Europe the cutting is regularly done with a sickle, and continued daily as the pods turn brown. The plants are laid on the ground in piles, with the pod ends toward the center.

These piles remain in the field several days, until sufficiently dry, when they are hauled into the barn upon sheets spread in the wagon. To prevent a waste of seed in loading, a large sheet is also spread on the ground by the side of the rows as they are lifted into the wagon. Rape should be harvested in a dry season, else much of the seed will be lost, some loss being sustained with the best of care.

If the weather is favorable, the seed may be thrashed in the field upon a large sheet of canvas. It should be spread out about 4 inches deep on the floor of the granary and turned over daily for a week or so, to prevent heating and molding.

The yield varies greatly, being in Germany from 1,800 to 2,600 pounds per acre. One bushel of seed yields 16.4 to 21 pounds of oil and 29.5 to 36.4 pounds of oil cake. In addition to this, 225 pounds of straw and pods are reckoned to every hundredweight of seed. In Europe the straw and pods are mixed with potatoes and used for fodder.

In this country some varieties of rape, especially that known as the Dwarf Essex, are being cultivated to a slight extent for forage, but so far as we know rape has not yet been grown in the United States for seed.

Rapeseed could be successfully raised in any of the Northern or Western States; probably in the South also. The only question is whether the industry would be a profitable one on account of the immense extent to which it is carried on in Europe, where labor is cheaper. Considering the great demand for rapeseed as bird food, as well as for oil, and the good price it brings, its culture seems well worthy of a trial. It must be borne in mind that the varieties of rape useful as forage are of no value for seed; hence it must be cultivated solely for one purpose or the other.

The seed of the wild mustard, or charlock (*Brassica sinapistrum*), a serious weed in some parts of the West, yields an oil similar to that of rapeseed. The same is true of false flax (*Camelina sativa*), which

is often found as a weed in flax fields. Other members of the mustard family, as black mustard (*Brassica nigra*), white mustard (*Sinapis alba*), radish (*Raphanus sativus*), etc., furnish oil-producing seeds and are cultivated to some extent for this product.

POPPY.

Poppy-seed oil is furnished by the seeds of the opium poppy (*Papaver somniferum*), an annual plant, originating in Asia, where it is cultivated very extensively, principally for the juice derived from its capsules, but also for its seed. The seeds (fig. 36) are less than a millimeter in length, kidney-shaped, with the surface regularly pitted, giving them a beautiful appearance under a lens. There is a black-seeded and a white-seeded variety under cultivation.

Fifty per cent of oil is obtained from the seeds by warm and 30 per cent by cold pressure. It is pale yellow, with a bland and slightly sweetish taste, totally destitute of narcotic properties. Poppy-seed oil is used for salads, paints, soaps, illumination, and to adulterate olive and almond oils. It is worth 35 cents a pound in this country, the white-seeded variety yielding the best oil.

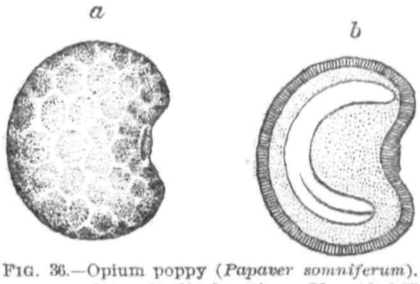

FIG. 36.—Opium poppy (*Papaver somniferum*). *a*, seed; *b*, longitudinal section. Magnified 25 times.

The plant thrives in a dry, warm climate, requiring no more care than corn. It does well in almost any dry soil if it is not too heavy, preferring a light, friable clay containing some lime. Well-rotted stable manure should be applied, but if the soil is rather light, soluble phosphates will be found to greatly increase the seed crop.

Sowing should take place early in the spring, since the poppy requires about five months to mature its seed. The seed germinates slowly, often requiring four weeks if the weather is cold, while in warm weather two weeks is sufficient. The seed should be drilled in rows, 12 to 18 inches apart, fresh seed saved from large, plump capsules being used. Under no circumstances should the black and white varieties be sown together, as this lessens the value of the crop. On soil which is medium heavy scarcely any covering is needed, and on the lightest soils the seeds should not be sown more than one-half inch deep.

After a good stand is secured, the plants should be thinned out to 4 or 6 inches, or even more. They are then treated the same as any hoed crop. The poppy is remarkably free from insect and fungous attacks; hence under ordinarily favorable conditions the seed crop is certain.

Harvesting should take place when the pods become leathery and the seeds begin to rattle in them. Dry weather must be chosen for this purpose, and under no circumstances should the seeds be allowed to get wet. The workman walks along the rows and shakes the ripe seeds into a bag which he carries. This is repeated every six or eight days until the entire crop is harvested. Then the plants are cut, bound in loose shocks, and allowed to dry. In Europe they are used for straw and fertilizer, but are not suitable for fodder. The seeds are carefully dried and are then ready for market. An average crop is said to be from 1,000 to 1,200 pounds per acre, yielding about one-half this weight of oil.

In addition to various portions of Asia, where poppy growing is the principal industry, a considerable amount of seed is raised in northwestern France, and some in Germany. It would probably do well in the southern and southwestern parts of this country.

The Mexican poppy (*Argemone mexicana*), which is widely distributed throughout the globe, and an abundant weed in California and other sections of the United States, is grown for oil in some countries.

OTHER OIL-PRODUCING SEEDS.

Among other plants whose seeds furnish oil, the following may be mentioned as growing in the United States, either wild or under cultivation: Melon, soja bean, maize, tobacco, fennel, dill, anise, parsley, caraway, coriander, celery, lovage, and wormseed (*Chenopodium anthelminticum*). Oils from some of these seeds are used in the preparation of medicines, and bring a good price. Whether their cultivation would prove profitable at the present time can be decided only by experiment.

The following quotations, from a recent number of the Bulletin of Pharmacy, will afford an idea of the relative value of some of the oils mentioned in this article:

Oil:		Price.
Anise	per pound	$2.35
Caraway	do	1.80
Castor	per gallon	1.95
Castor (machine)	do	1.10
Coriander	per ounce	1.25
Cotton-seed	per gallon in barrels	.43
Croton	per pound	1.20
Fennel	do	1.65
Linseed (boiled)	per gallon in barrels	.48
Linseed (raw)	do	.45
Poppy	per pound	.35

SOME ADDITIONS TO OUR VEGETABLE DIETARY.

By Frederick V. Coville,
Botanist, U. S. Department of Agriculture.

Up to the present time chemistry has shown in a general way what substances are required for building and repairing the body, for keeping it warm, and for making it work. It has shown, too, approximately, what amount of lean meat, fat meat, flour, sugar, etc., ought to produce the desired result, but it has not yet shown in detail what kinds of these various types of food will suit the taste, digestion, and physiological needs of particular persons or particular conditions. An exclusive diet of salt meat and beans in the arctic region produces the physiological condition known as scurvy. In some parts of the country a diet of corn bread, bacon, and molasses has been persisted in to such an extent as to produce a widespread and almost chronic condition of biliousness. The conclusion from such cases is that in the selection of foods we must take into account the appetite, power of digestion, and physiological peculiarities of the individual; in these matters each man is necessarily his own judge. There seems little doubt, in general, that a wider use of green vegetables in the dietaries of most of our people, particularly those with healthy digestion, would be a marked benefit.

In the year's diet of wild herbivorous animals, the fats and the carbohydrates, principally stored in seeds in the form of oil and starch, furnish the chief foods in autumn, and on them the animals fatten, providing themselves with the necessary store of bodily fuel for the winter. In the spring, when they have usually exhausted this stored fat, their principal food is green herbage, and upon this they renew their muscular vigor and general vitality. A similar yearly routine prevails among savage races, as illustrated by many tribes of our Western Indians. So far as the naturalness of a diet of green vegetables is concerned, there can be no doubt that it formerly was and that it still is adapted to the requirements of the human body. But since the beginning of civilization the food of mankind has come to be more and more artificial in character, until foods are now selected more by custom than by instinct. The habit of eating salads and boiled green vegetables, commonly referred to as pot herbs or

greens, is much more prevalent in Europe than in America, and to the lack of this kind of food, it is believed, is due in large part the reputation of Americans as a bilious race. Of course, like all nations, we eat a large amount of plant food, but by far the greater part of it is derived from seeds, roots, and tubers.

All pot herbs are properly gathered in the early period of the plant's growth, when the green parts are relatively rich in formative and nutritious materials. The percentage of protein compounds in the dry matter is then large, compared with its later stages, for the plant at this time is engaged in the manufacture of the substances necessary for its own later development, which are largely similar to those required in the building up of the human body. It must be borne in mind, on the other hand, that more than four-fifths, by weight, of the substance of green vegetables is made up of water. Care should always be taken in gathering or selecting pot herbs that the plants are young and have not become tough and stringy by the transformation of their formative materials into cellulose or other indigestible and perhaps deleterious substances. In preparing them for the table they should be boiled, the time varying from only a few minutes, in the case of a very succulent and mild plant, to two and even three hours, in the case of a plant with thick, firm tissues or containing a bitter principle. The latter defect must be removed by long boiling and the repeated changing of the water. The details of cooking are the business of the cook, and in the following pages only such references to this subject will be made as are specially called for by some peculiarity of a particular plant.

FIG. 37.—Charlock (*Brassica sinapistrum*).

SWISS CHARD (*Beta vulgaris*).—This variety of the common beet has been cultivated and selected in such a way that the principal development of the plant takes place in the leaves instead of the root. The plant is sometimes called, therefore, leaf beet and sometimes spinach beet. After sowing in spring the plants are thinned, like beets, and well supplied with water. In late summer, autumn, and, in more southern climates, in early winter, the leaves are in condition for use. The leaves of the ordinary beet are also used as a pot herb, but only in spring and early summer. Beets when raised for their

roots are sowed in drills, and as the plants increase in size the rows are thinned to the proper extent, the young plants being pulled from time to time, roots and leaves together, for boiling.

CHARLOCK (*Brassica sinapistrum*).—This plant occurs as a weed across the northern part of the United States, from New England to the State of Washington, and is most troublesome in regions like Wisconsin, Minnesota, and North Dakota, where spring wheat is extensively cultivated (fig. 37). It is a near relative of the black mustard, commonly occurring with it as a field weed, but may be distinguished by its large pods, which when mature are 1 to 2 inches in length, those of black mustard scarcely exceeding half an inch. Charlock was commonly used as a pot herb in northern Europe centuries ago, but in America it has not, so far as known, been employed for that purpose. Indeed, in some parts of central New York, where it is distinguished from its relative under the name "wild mustard," it is commonly reputed to be poisonous, and is carefully avoided in gathering the young mustard plants. Charlock and black mustard must not be confounded with yellow rocket and its relative, winter cress, the latter of which is described hereafter.

FIG. 38.—Chicory (*Cichorium intybus*).

CHICORY (*Cichorium intybus*).—This plant, the ground and roasted root of which is used in small amounts to improve the flavor of coffee and in larger amounts as an adulterant or substitute for it, occurs as a weed in the Atlantic States and on the Pacific Coast, and locally in the interior (fig. 38). Thus far it is confined principally to the vicinity of cities and towns, and has not yet become generally diffused. It is closely related to the cultivated endive (*Cichorium endivia*), a common salad plant. Chicory is a biennial, which in its second year throws up a stiff, branching, almost leafless stem 2 to 4 feet high. In late summer and autumn it bears large numbers of blue flower heads about an inch in diameter and similar in shape to those of a dandelion, which open in the early morning and close after a few hours' exposure to the sun. During the whole of its first year it sends up no stem, but its leaves grow in a rosette upon the ground, closely

resembling those of a dandelion, but larger. In the spring of the second year the plant bears a still larger tuft of these leaves, which is soon followed by the flowering stem. The root leaves in their young state are the parts used as a pot herb. They contain a bitter principle and require the same process of cooking as the dandelion.

WINTER CRESS (*Barbarea praecox*).—This plant and the yellow rocket (*Barbarea barbarea*) often pass under the general name of mustard, but the two species may be easily distinguished from the true mustards by the form of their leaves, as well as by the technical difference shown in the cross section of the seed (fig. 39). Yellow rocket is a well-established weed in the Eastern States, having been introduced from Europe. It occurs also as a native plant upon the higher mountains from the Atlantic to the Pacific. Winter cress is in common cultivation from the vicinity of New York City southward, and to some extent reseeds and maintains itself without assistance, but it can hardly be considered under these conditions a real weed. In the city of Washington it is marketed extensively as a winter salad and pot herb. The seed is sowed in late summer after some early crop, or at the time of the last cultivation of an early fall crop, such as cabbage. It is usually sowed broadcast and is given scarcely any cultivation except the pulling of weeds. Yellow rocket itself is rarely used in this country as a pot herb.

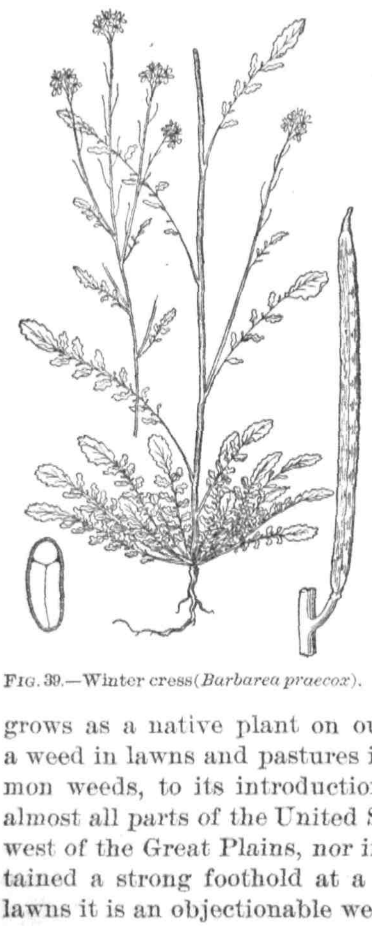

FIG. 39.—Winter cress (*Barbarea praecox*).

DANDELION (*Taraxacum taraxacum*).—The dandelion is too well known to require any description. Although, like the yellow rocket, it grows as a native plant on our higher mountains, its occurrence as a weed in lawns and pastures is due, as with most of our other common weeds, to its introduction from Europe. While it occurs in almost all parts of the United States, it is not a common plant in and west of the Great Plains, nor in the extreme south, though it has obtained a strong foothold at a few points on the Pacific Coast. In lawns it is an objectionable weed, not so much on account of its unsightliness as because, from its spreading habit, it chokes out the proper lawn plants. It is not generally known that the market gardeners in the vicinity of Paris have been cultivating the dandelion

for the past twenty-five years, and that at least three horticultural varieties have been developed within that time. In the United States, however, the dandelion is seldom cultivated, though eaten almost everywhere. The customary use of the dandelion in Paris is as a salad, the plants being eaten either green or blanched. When used as a pot herb the water in which the plants are boiled is changed two or three times during the process in order to remove the bitter taste.

DOCK (*Rumex*, of various species).—Two species of dock, the broad-leafed (*Rumex obtusifolius*) (fig. 40) and the curled (*R. crispus*), are common weeds in pastures, meadows, and cultivated fields, the former extending from New England to the Great Plains, the latter quite across the country. Both are perennials whose root leaves in spring are often used as a pot herb, sometimes alone, sometimes mixed with dandelions or other plants. Patience dock (*R. patientia*) is widely cultivated in Europe as a pot herb, and is grown in America also to some extent for the same purpose, but it seldom appears in our markets. In many places in New England and New York it has escaped from old gardens, where it was often known as "herb patience," and has become established as a weed in meadows. Sorrel dock (*R. acetosa*), or simply sorrel, as it is usually called in England, has appeared in the United States as a weed in only a few places, the plants commonly known here as sorrel being our native *R. hastatulus* of the Middle Mississippi Valley region, and the introduced *R. acetosella* which occurs on poor soils everywhere east of the Great Plains. Neither of these two species appears to be used as a pot herb, and they would probably not be satisfactory for such a purpose. But the true sorrel dock is in common cultivation in Europe, being grown either from seed or by root propagation. This is the most acid of the plants used as pot herbs, nearly all the docks containing, in greater or less amount, an acid principle similar to that of the common pie plant or rhubarb. The fact that the young leaves of one of our native docks, *R. berlandieri*, were used as a pot herb by the American aborigines, more particularly the Pimas and Maricopas, is not generally known.

FIG. 40.—Broad-leafed dock (*Rumex obtusifolius*).

The leaves are gathered when the plant is a few inches high and eaten either boiled or raw. They have an acid taste, in this respect resembling the sorrel dock. Growing as it does in the arid region of Arizona, New Mexico, and Texas, where succulent vegetation is scarce, it is well worth a trial as a table vegetable.

KALE (*Brassica oleracea acephala*).—Kale, essentially a cabbage plant that does not form a head, is a common market pot herb. It bears several names, including borecole, German greens, Georgia collards, Gallega cabbage, in addition to many descriptive names of varieties. Like cabbage, it requires thorough cooking, and is less easily digestible than many other pot herbs. The young leaves of the turnip (*Brassica rapa*), either green or blanched, are frequently used as a pot herb, particularly in the South. They closely resemble some of the varieties of kale in both appearance and taste.

FIG. 41.—Lamb's-quarters (*Chenopodium album*).

LAMB'S-QUARTERS (*Chenopodium album*).—This is a common weed in cultivated fields and gardens, extending almost throughout the United States (fig. 41). It is more commonly known as pigweed, or sometimes as goosefoot, and is to be distinguished from the true pigweed described hereafter not only by technical botanical characteristics but by the fact that the herbage, particularly when young, bears a more or less abundant mealy coating, giving the whole plant a pale bluish-green color. In its young stage, when 6 or 8 inches high, the plant is very tender and succulent, and in Europe, as well as in some parts of our own country, has often been employed as a pot herb. Indeed, its botanical relationship would indicate its adaptability to such a use, since it belongs to the same family as the beet, spinach, orach, and mercury. This is perhaps the most widely diffused and commonest of the weeds which might be used for human food. The plant is an annual, and as a weed is not difficult to keep in check. In cooking, boil for about twenty minutes.

MARSH MARIGOLD (*Caltha palustris*).—This plant, which in the United States bears more commonly the name "cowslip," is a native of the northern United States and British America, extending from New England to Minnesota and northwestward to Alaska (fig. 42). It grows in cold swamps and wet meadows, shooting up in the spring through the shallow water. Locally it is used among the country-

people as a pot herb, the plants being gathered when they are in bud or just as the flowers begin to open. By many it is considered superior to any other plant used in this way. From the surroundings in which it grows it is almost sure to be free from dirt or sand, and to this fact, in part, is doubtless due its popularity, for it is very much more easily handled by the cook or housewife than are plants which require repeated washings.

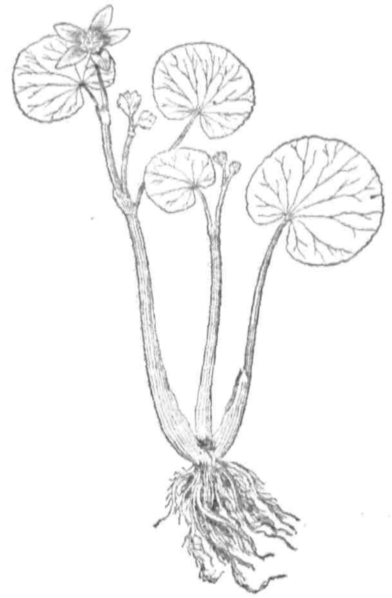

FIG. 42.—Marsh marigold (*Caltha palustris*).

MERCURY (*Chenopodium bonus-henricus*).—Mercury, more commonly pronounced "markery," is one of the common cultivated pot herbs of Europe, and to some extent, has been introduced into our gardens. It shows little tendency to spread as a weed, and is not likely to become generally abundant in the United States. Its value as a pot herb is about the same as the related species, lamb's-quarters. Besides these two species of Chenopodium, or goosefoot, the use of which for food has been taught us by Europeans, we have in our Western country several other species, among them *C. fremonti* and *C. leptophyllum*, both of which are native to the United States. There is little doubt that either of these, gathered at the proper season and suitably cooked, would be equally palatable.

FIG. 43.—Black mustard (*Brassica nigra*).

BLACK MUSTARD (*Brassica nigra*).—This plant, from which the condiment known as mustard is chiefly derived, has long been cultivated in Europe for its young leaves (fig. 43). In our own country it was introduced many years ago as a weed in fields, and in some regions, more particularly in California, where it passes under the general name of "wild mustard," it has become a thorough pest in wheat fields. So easily does it seed itself that it is

rarely, if ever, really cultivated in the United States, although small areas in the corners of gardens are often left without cultivation as a "mustard patch." Its value as a honey-producing plant has added further to its desirability on farms. In hoed crops it is not difficult to keep in check.

ORACH (*Atriplex hortense*).—This is an occasional garden substitute for spinach, though it rarely appears in market. Several varieties are grown in Europe, which differ principally in color, the stem and leaves varying from the ordinary bright green to a pale yellowish green with white stems or to a dark reddish purple. The plant is a native of Tartary and shows no tendency to become established as a weed.

FIG. 44.—Pigweed (*Amarantus palmeri*).

PIGWEED (*Amarantus palmeri*).—None of the common pigweeds introduced from tropical America and common in our cultivated fields, such as *A. retroflexus* and *A. chlorostachys*, appear to have come into use as pot herbs, although a variety of *A. gangeticus* is commonly cultivated by the Chinese in California for this purpose. Among our Southwestern Indians, both in Arizona and in northern Mexico, as well as among the Mexicans themselves, a native species, *A. palmeri*, is used largely in a similar manner (fig. 44). In the markets of Guaymas, in the State of Sonora, it is sold in large quantities, the young plants growing each year from seed and being gathered when they are from 6 to 10 inches high. No attempt seems to be made to cultivate the plant, the Mexicans trusting entirely to the natural supply. From the suggestive use of these species of pigweed among the Chinese and the Mexicans, a trial of some of our other species may well be made.

POKEWEED (*Phytolacca decandra*).—This is a native plant of the United States, growing throughout almost all parts, except the extreme north, as far westward as the Great Plains. It occurs commonly in rich, uncultivated ground, in open places in woods, or in almost any neglected spot. The stems reach a height of from 4 to 8 feet and bear drooping clusters of purple berries. The root is perennial, shaped somewhat like a beet, and in age becomes very large. It contains a deadly poison, which is used medicinally, and in some cases has caused accidental death. The berries, while reputed to be poisonous, are often eaten by birds, and are presumably quite harmless. In early spring the stout stems push out from the ground and are cut when only 2 to 4 inches in height. They are thick and succulent like the stems of asparagus, and are not only used by country people, but are commonly brought into the city markets, where

they are sold under the name of "sprouts." From the extremely poisonous nature of the root it is evident that care should be taken in using the plant. But the fact that they are always cooked practically removes any danger from this source, as the poisonous principle of the roots is dispelled in the boiling process. The roots, however, are bitter, and if portions remain attached to the stem the taste of the boiled herb is often disagreeable. In Mexico the plant occurs frequently about old missions, suggesting a former use of some kind, but at the present time it does not appear to be employed there as a pot herb. In the United States it is not cultivated, in the proper sense of the word, although those who bring it into the markets are careful to allow it to maintain itself in the areas in which it becomes established. The French, however, always apt in testing and making use of every kind of food, have introduced the plant into cultivation in Europe.

PURSLANE (*Portulaca oleracea*).—The common garden purslane, more commonly known as "pusley," occurs as a weed in almost every garden in the United States, yet rarely does one meet with a person who has ever eaten it or who knows of its use as a pot herb. The plant is a native of India, has been cultivated from the earliest times, and was such an early accompaniment of civilization as to have a Sanskrit name. It was carried westward to Europe, and has there been in use for centuries as a salad and pot herb. Indeed, several varieties are now known in cultivation. In the United States, however, it is known only as a weed, its principal economic value being supposed to be as a food for hogs, a purpose to which large quantities of it are devoted. Notwithstanding this use, it is treated as a weed, not as a forage plant. As a pot herb, however, it is very palatable, still retaining, when cooked, a slight acid taste. It can be heartily recommended to those who have a liking for this kind of vegetable food.

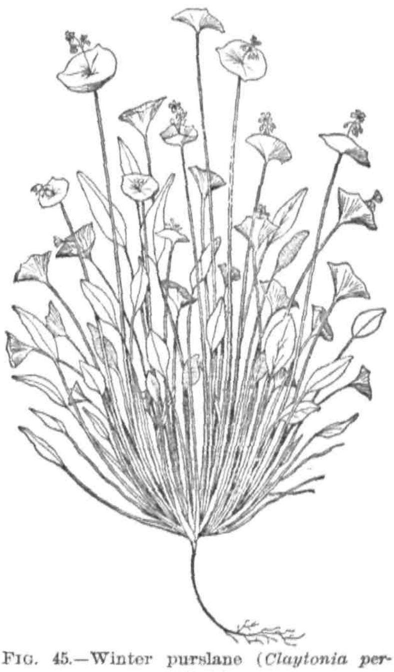

FIG. 45.—Winter purslane (*Claytonia perfoliata*).

WINTER PURSLANE (*Claytonia perfoliata*).—In mountain regions from the Rocky Mountains westward to the Pacific occur several varieties of Claytonia more or less resembling the two well-known species of the eastern United States called "spring beauty." The most widely

diffused and representative among the western species is *C. perfoliata* (fig. 45). For many years this has been in use as a pot herb, though a knowledge of its employment for this purpose appears to be confined to restricted localities. The same species or a closely related one is reputed to occur in Mexico and in Cuba, and from the latter country it has been introduced into cultivation in Europe. The members of the Death Valley expedition in California in 1891 used large quantities of this plant when they came out of the desert and ascended the mountains to the west, having lived for several months without green vegetables of any kind.

SPINACH (*Spinacia oleracea*).—The common garden spinach cultivated everywhere in Europe and the United States may be considered the typical pot herb of these two countries. The plant, which was unknown to the Greeks and Romans, is believed to have originated in Persia and to have been carried both westward and eastward, ultimately finding its way to China as well as western Europe and America. It is an annual of quick growth, producing in early summer a large number of triangular root leaves arranged in a rosette. Several varieties of spinach are known in cultivation, as, for example, prickly-seeded spinach, Flanders spinach, and lettuce-leafed spinach. In the southern United States it is grown as a winter vegetable, the seed being sowed in August or September, and mulched with straw or salt hay. Under such conditions it produces a good crop during the late autumn and winter months.

NEW ZEALAND SPINACH (*Tetragonia expansa*).—This plant, which originated in New Zealand, was brought to Europe by Captain Cook in his voyage around the world, and has since been cultivated there to a greater or less extent. It is an annual, with spreading branching stems and inconspicuous green flowers. Unlike spinach, it continues to produce a crop of succulent leaves during the whole summer, and therefore is useful as a pot herb in the hot season, when almost all other plants so employed are not available. It will also withstand a considerable drought, and for this reason is especially useful in regions of limited rainfall. It would probably prove one of the most successful pot herbs for general cultivation in many parts of our western subarid region.

The plants enumerated here do not by any means comprise all the species that might be used as pot herbs, but they have been selected so as to suggest to people in every part of our country certain plants growing in their own region which are available for use in this manner. Doubtless others, particularly among our native plants, such as the common nettle, milkweed, and the round-leafed mallow, commonly known to children as "cheeses," will be found equally important.

HEMP CULTURE.

By Chas. Richards Dodge,

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In the literature of the fiber-producing plants of the world the word hemp appears frequently, applied oftentimes to fibers that are widely distinct from each other. The word is usually employed with a prefix, even when the true hemp is meant, as manila hemp, sisal hemp, Russian hemp, etc. In this article will be considered the hemp plant proper, the *Cannabis sativa* of the botanists, which has been so generally cultivated the world over as a cordage fiber that the value of all other fibers as to strength and durability is estimated by it. In many of the experiments of Roxburgh and others we find "Russian hemp" or "best English hemp" taken as standards of comparison.

The Sanskrit name of the plant is bhanga; in Hindostan it is called ganja; the Arab name is kinnub, from which, doubtless, its Latin name, cannabis, is derived; in Persia it is known as bung, while in China it is chu ts-ao, and in Japan, asa.

Its native home is India and Persia, but it is in general cultivation in many parts of the world, both in temperate and more tropical climes, though only in Russia and Poland in large quantities for export. French hemp is much valued, but the finest quality comes from Italy, and is pronounced fine, soft, light colored, and strong. Hemp grows in all parts of India, and in many districts flourishes in a wild state. It is but little cultivated for its fiber, although Bombay-grown hemp "was proved to be superior to the Russian." In portions of India, as well as other hot countries, it is cultivated for its narcotic products, the great value of which makes the India cultivators indifferent about the fiber. Hemp is largely grown in Japan for the manufacture of cloth. This industry is very old, as prior to the introduction of silk weaving it was the only textile fabric of the country.

Its cultivation is an established industry in the United States, Kentucky, Missouri, and Illinois being the chief sources of supply, though the culture has extended as far north as Minnesota and as far south as the Mississippi Delta, while California has recently become interested in its growth.

Several varieties are cultivated in this country, that grown in Kentucky, which has a hollow stem, being the most common. China hemp, with slender stems, growing very erect, has a wider range of

culture, and Smyrna hemp is adapted to cultivation over a still wider range, but is not so well known. A small quantity of seed of the Piedmontese hemp of Italy was distributed by the Department of Agriculture in 1893, but the results of the experiments were not fully successful.

Formerly large areas were devoted to the cultivation of the plant in the United States, and thirty-five years ago nearly 40,000 tons of hemp was produced in Kentucky alone, while now hardly more than a fourth of this quantity is produced in the whole country. There are several reasons for the decline in production in the United States, but it dates back, primarily, to the decline in American ship-building and to the introduction of the Philippine Island hemp (*Musa textilis*), the manila hemp of commerce, and later to the large importation of jute. Quite recently there has been a further falling off in production, and it is worthy of note that this is largely due to the overproduction of this same hemp of Manila, brought about by the high prices of the latter fiber in 1890-91, a direct result of the manipulation of the fiber market by certain binding-twine manufacturers.

Formerly the hemp of Kentucky was not only used for the rigging of vessels, and in twines or yarns, and bagging, but it was spun and woven into cloth, just as to-day it is manufactured into fabrics in portions of Brittany.

About 1890, when the Department of Agriculture became interested in extending the cultivation of hemp, and when the consumption of binding twine amounted to 50,000 tons annually, it was shown that, at the prices then prevailing, if one-half of the binding twine were made of common hemp grown at home, and not from manila or sisal, there would be a clear saving to the consumers of $1,750,000 in a year, with the further advantage that American farmers would produce the raw material. There was a cry that "soft twines" would not work in the self-binders, though the Office of Fiber Investigations was able to show that common hemp twine could be employed quite as satisfactorily as the stiffer twines, and that the prejudice had no substantial foundation.

In the past two years there has been an increasing demand for information relating to hemp culture, and experiments looking to its production have been carried on in localities where previously its culture was unknown, notably in extreme Southern States, which are large producers of cotton.

SOIL SELECTION.

As in Brittany, so in Kentucky, limestone soils, or the alluvial soils such as are found in the river bottoms, are best adapted to this plant. The culture, therefore, is quite general along the smaller streams of Brittany, where the climate is mild and the atmosphere humid. In

Kentucky the best lands only are chosen for hemp, and the most favorable results are obtained where there is an underlying bed of blue limestone. In certain portions of the State, Shelby County for example, it is claimed that a finer and tougher fiber is produced than in other sections, and this is thought to be due to a mixture in the soil of a whitish, oily clay. As a general rule, however, light or dry soils or heavy, tenacious soils are most unfavorable.

Hemp is not considered a very exhaustive crop. In a former report *it was stated by a successful Kentucky grower that virgin soil sown* to hemp can be followed with this crop for fifteen to twenty years successively; sown then to small grain and clover, it can be grown every third year, without fertilizers, almost indefinitely.

In France a rotation of crops is practiced, hemp alternating with grain crops, although competent authorities state that it may also be allowed to grow continuously upon the same land, but not without fertilizers. Regarding this mode of cultivation, they consider that it is not contrary to the law of rotation, as by deep plowing and the annual use of an abundance of fertilizers the ground is kept sufficiently enriched for the demands which are made upon it. If the soil is not sufficiently rich in phosphates or the salts of potassium, these must be supplied by the use of lime, marl, ground bone, animal charcoal, or ashes mixed with prepared animal compost. Even hemp cake, the leaves of the plant, and the "shive," or "boon," may be returned to the land with benefit. This high fertilizing is necessary, as "the hemp absorbs the equivalent of 1,500 kilos of fertilizers per every hundred kilos of fiber obtained."

In Japan, where most excellent hemp is produced, the ground is given a heavy dressing of barnyard manure before it is plowed in November. After the soil has been well pulverized and reduced to fine tilth, the seed is drilled and the land given a top dressing composed of one part fish guano, two parts wood ashes, and four parts animal manure. The proportions and the quantities used differ, of course, upon different soils.

In New York, where hemp was formerly grown, barnyard manures or standard fertilizers are used, as it is considered essential to put the soil in good fertility to make a successful crop. In Illinois, with the method of cultivation in vogue, it is not regarded as in any way exhaustive to the soil, though the refuse must be returned if possible. A Kentucky practice is to burn the refuse and spread the ashes over the land.

As in flax culture, a careful and thorough preparation of the seed bed is important, for the finer and more mellow the ground the better will be the fiber. This is better understood in Europe than in America, however, for American hemp is coarse, and its chief use, in a cordage fiber, does not make fineness an essential; in fact, American hemp is more nearly like the hemp of Russia, with which it competes.

Soil preparation in the blue-grass region of Kentucky consists in a fall or early spring plowing, and a short time before seeding, which in general terms is about corn-planting time, the ground is thoroughly pulverized by means of an improved harrow, such as the disk harrow, after which it is made smooth. The date of planting varies according to whether the soil is wet or dry, and may range from the last week in March to the last week in April, or even the 1st of May.

In Brittany, after the harrow and roller are used, small lines of trenches or furrows are dug about 10 feet apart for drainage purposes, after which the surface is cleared of weeds and the seed sown in drills. The drill is likewise used in Illinois, though the most common practice in Kentucky is to sow broadcast, followed by a light harrowing and sometimes by a light drag to level the surface.

A correspondent states that many farmers in Shelby County, Ky., use the ordinary grain drill for broadcast seeding. The rubber pipes are removed from the drill, and a board is attached directly beneath the hopper. The seed falling upon the board is scattered in front of the drill hoes, which do the covering. A light drag passed over the field levels and evens the surface, after which nothing is done until the hemp is ready for the harvest.

The quantity of seed sown to the acre varies. One large grower says 33 pounds of seed per acre is the proper amount. Another states that 1 to 1¼ bushels is his rule. In New York 1 to 3 bushels have been sown (in past time), 1 bushel giving better results than a larger quantity. In Illinois it varies from 1 to 2½ bushels.

In France a difference is made regarding the use to which the fiber will be put, a third more seed being sown for spinning fiber than for cordage fiber. On a farm in Sarthe, visited by the writer, a little less than 3 bushels to the acre was the usual quantity sown, but as high as 4 bushels are sown on some farms.

There will be little trouble with weeds if the first crop is well destroyed by the spring plowing, for hemp generally occupies all the ground, giving weeds but little chance to intrude. For this reason the plant is an admirable weed killer, and in flax-growing countries is sometimes employed as a crop, in rotation, to precede flax, because it puts the soil in good condition. In proof of this, a North River farmer a few years ago made the statement that thistles heretofore had mastered him in a certain field, but after sowing it with hemp not a thistle survived, and while ridding his land of this pest the hemp yielded him nearly $60 per acre where previously nothing valuable could be produced.

HARVESTING.

In Kentucky the hemp stalks are considered ready to cut in one hundred days, or when the first ripe seed is found in the heads. The cutting is usually done with a hooked implement, or knife bent at

right angles about 24 inches from the hand. In recent years, however, the work is sometimes done by machines adapted to the purpose, and particularly when the stalks are slender.

In France there are two modes of harvesting, dependent upon the use to which the fiber will be put. If the fiber is for cordage, the stalks are cut with a sharp instrument resembling a short scythe, and laid upon the ground in sheaves, where they are left to dry from one to three days. The leaves are then stripped and the stalks removed to the sheds, to be assorted, and then placed in piles horizontally, the lower ends of the stalks being pressed firmly against a wall, so that the inequalities of their length may plainly appear. Upon each pile there is placed close to the wall a weight, to prevent deranging the stems while drawing them out in assorting. This is done by handfuls; first the longest stems, then the medium, and then the short ones. They are bound into sheaves, several of which are put together, forming bundles, each containing stalks of equal length. The tops of the sheaves are then cut off, and only the portion preserved that will make good fiber.

When the hemp is grown for use in spinning—that is, for fabrics—the stalks are not cut, but are pulled like flax. The operator first removes the leaves by passing his hand from top to bottom of the stalk, it being important to return the leaves to the soil where they were grown. Six to fifteen stalks are pulled at one operation, according to the ease with which they can be drawn out of the ground, and the earth shaken off. These handfuls are made into bundles about 6 inches in diameter, and the roots and tops are then removed by means of an ax and chopping block. The clipped stalks are then made up into larger bundles a foot or more in diameter, and are sent to be retted at once, as it is claimed that the hemp is not so white if it is dried before retting.

Hemp is probably never pulled in this country. When the stalks are cut they are laid in rows, even at the butts, and are allowed to remain on the ground, not over a week, to dry—only long enough, as one correspondent expresses it, to get a rain on the leaves, so that they will drop off readily. Where the rain is too long deferred, however, the hemp should be put in shocks, or small stacks, having been first made into bundles of convenient size for easy handling.

Hemp is dew retted in this country; that is, spread evenly over the ground to undergo the action of the elements which dissolve or rot out the gums holding the filaments together. Formerly pool, or water, retting was practiced in a very small way in Kentucky and to a slight extent later in Illinois. It is said that Henry Clay introduced the practice into the former State, but it was not followed. It is true, however, that the manufacturers formerly preferred water-retted hemp, and the Navy Regulations required it, but the price of cordage hemp hardly warranted the extra labor and consequent expense.

The hemp is allowed to remain in stack until November or December, or about two months, when it is spread over the ground until retted. No rule can be given regarding the proper length of time that the hemp should lie, as this varies according to the weather, sudden freezing, followed by thaws, hastening the operation. It is usually allowed to lie until the bast separates readily from the woody portion of the stalk. When there is a large crop, there may be an advantage in spreading the hemp earlier than November, in order that the breaking may be done in the winter months. Winter-retted hemp is brighter, however, than that retted in October. It is usually stacked and spread upon the same ground upon which it is grown, and when sufficiently retted, as can be determined by breaking out a little, it is again put into shocks. If the hemp be dry, the shocks should be tied around the top tightly with a band of hemp to keep out the rain. The shocks are made firm by tying with a band the first armful or two, raising it up and beating it well against the ground. The remainder of the hemp is set up around this central support. By flaring at the bottom, and tying well, a firm shock can be made that will stand firmly without danger of being blown over by the wind.

Dew retting is practiced to some extent in France, though water retting gives better results. The practice, called "rouissage," is accomplished both in pools and in running streams. The river retting seems to accomplish better results, although taking a little longer time than the pool retting, the duration of immersion varying from five to eight days. If the weather is cool, it retards the operation two or three days longer than if warm. This accounts, too, for the shorter time occupied when the immersion takes place in pools. This work is usually done in the latter part of August. The bundles of hemp are floated in the water, secured if in a running stream, and are covered with boards kept in place by stones or any weight that will keep them under. There appears to be little pool retting in the Sarthe district, although public opinion is generally against river retting on the score of its rendering the waters of the streams foul and detrimental to health, as well as destructive to all animal life with which they would otherwise abound. It is understood that there are very stringent police regulations against the use of streams for this purpose, and as long ago as 1886, in a brochure published by M. Bary, a hemp spinner of Le Mans, attention was called to the desirability of introducing an improved method of retting which would accomplish all the beneficial results of retting in running water artificially, and therefore render unnecessary the polluting of streams. While many attempts have been made to bring about a better system, none have been successful, and, police regulations to the contrary notwithstanding, the best hemp fiber produced in the Sarthe district is still retted in the running streams. Where pool retting is followed, the pools are specially constructed, dug out of the

earth to the depth of a yard or more, walled up or the sides made solid, and lined and floored with cement usually in order that the water shall remain clean and the hemp retain its color. The stalks are watched very closely after the third or fourth day, the farmer breaking and examining a few at intervals to guard against over-retting, which weakens the fiber.

When sufficiently retted, whether the work is done in streams or pools, the hemp bundles are removed from the water, but first agitated to remove all waste matter that may be adhering to the stalks. They are then drained, and the bundles, opened at the bottom, are set up in conical sheaves to dry, this operation being accomplished in two or three days. Considerable of the hemp grown, in the Sarthe district at least, is further dried in brickkilns.

The Japanese method of retting differs so materially from the practices followed in western countries that a brief statement will prove interesting. The raw hemp produced in Japan is usually sold in the form of thin, smooth ribbons, which are of a light straw color, the frayed ends showing a fiber of exceeding fineness. Some beautiful samples of this hemp were secured by the writer at the World's Columbian Exposition, with an account of the peculiar treatment of the stalks to produce the fiber.

In Japan hemp is ready for harvesting about one hundred and twenty days after sowing, or about the 20th of July. In harvesting, the plants are pulled, leaves and roots are cut off with a sickle, and the stems sorted into long, medium, and short lengths and bound in bundles. These bundles are steamed for a few minutes in a steaming bath specially constructed, and dried in a sunny situation for three days, when they are fit for keeping to be manipulated according to the condition of the weather, if favorable or unfavorable. If good, settled weather is anticipated, three bundles of the stems above mentioned are made into one bundle, exposed to the sun by turning upside down once a day for about three days, then dipped into water and exposed again to the sun for a number of days, until they are completely dried, when they are kept in a dry place for future work. For preparing the best quality of hemp fibers, the drying process takes thirty days, and for second and third qualities, fifteen and twenty-five days, respectively, are required. For separating hemp fibers from the stalk, the bundles treated as above mentioned are immersed in water and moderately fermented by heaping them upon a thick bed of straw mats in a barn specially built for the purpose. The number of hours depend much upon the temperature at that time; in short, the fermentation requires great skill. When the stalks are fermented to a proper degree, the fibers are separated by hand and immersed in water, the outer skin is scraped off by hand tools specially constructed, and dried in well-ventilated places by hanging the fibers on bamboo, without exposing to the sun.

BREAKING THE HEMP.

It is said that nearly 300 patents have been issued in the United States for machines for breaking hemp, many of them having proved absolute failures, while none of them have filled the requirements of an economically successful hemp-cleaning device. The fact remains, therefore, that the Kentucky hemp grower of to-day relies upon the rude and clumsy five-slatted hand brake of his grandfather's time, a device similar in all respects to that used for the same purpose at the present time by the hemp farmers of Brittany. In Kentucky the breaking is an expensive operation, costing $1 to $1.25 per short hundred pounds of fiber. The work is performed in the winter by negroes, and the best workers will not average more than 150 pounds in a day. In a former report on this subject a homemade machine employed for the purpose in Illinois was described as a very large brake with fluted rollers, the flutes being from 1½ to 2 inches deep. The cleaning cylinders were 5 feet in diameter of any desired width, with crossbars alternating with loose wings. In the crossbars were pins that acted as combs, these being about three-quarters of an inch long and bent back slightly. Under the cylinders were slats 2 inches apart through which the refuse fell. One cylinder was used close behind the brakes. The other two cylinders had each one pair of rollers in front to hold the fiber while the shive, or waste, was being cleaned out. The fiber was not delivered straight, but it was claimed that twine manufacturers preferred this product to straight Kentucky hemp fiber on account of its superior strength.

A number of patented machines possessing more or less merit have been brought to public notice in the past four or five years, several of which have been examined by this Department. In this brief account of the cultivation of hemp it is not important, however, to go into details concerning their merits or demerits, and the subject is left for future consideration. For the same reason no mention has been made of recent experience in the cultivation of hemp in the South and in California, though many facts of general interest might be presented.

The market prices for American rough hemp at the present time may be stated at $70 to $80 per ton for Missouri, and $125 per ton for Kentucky. No recent figures are at hand showing cost of production, but in 1890, counting a man and team worth $3.50 per day, the cost of producing an acre of hemp in Kentucky was shown to be about $24. The average yield is about 1,000 pounds per acre, but this is frequently exceeded by several hundred pounds.

CANADIAN FIELD PEAS.

By Thomas Shaw,

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The term Canadian field peas, or, as it is more commonly expressed, "Canada field peas," is used with much latitude in this country. Ask a pea grower in the United States as to the variety of seed which he sowed and the almost invariable answer given is: "I sowed Canada peas." That may mean that he grew any one of nearly one hundred varieties. The answer is significant. It implies, first, a great lack of knowledge with reference to varieties on the part of those who grow peas, and, second, that much of the seed used in the United States is imported from Canada, although we have large areas unrivaled in their adaptability to the growing of peas.

The pea crop is one of the most important in Canada. In the Province of Ontario alone the average area devoted to the production of peas for the thirteen years ending with 1894 was 691,392 acres. The average annual yield during the period named was 13,982,527 bushels, or an average of 20.2 bushels per acre; the greater portion of this crop is fed upon Ontario farms.

In striking contrast with the magnitude of the pea crop in Canada is its insignificance in our own country. While the area devoted to peas in Ontario is not far behind that devoted to winter wheat, the pea crop is so insignificant, relatively, in this country that it has not been given a fixed place in the Government crop reports. In Minnesota it is not mentioned in the yearbook of statistical returns, and the same seems to be true of nearly all the States in the Union. We are to-day importing much of our seed from Canada, in the face of an import duty of 20 cents per bushel.

VARIOUS USES OF THE PEA CROP.

No other grain crop except perhaps oats can be devoted to so great a variety of uses. The grain is possessed of a relatively high feeding value, and the same is true of the straw, as will be readily apparent by reference to the chemical analysis of each. As a pasture for certain kinds of live stock, peas may be made to serve an excellent purpose. The value of the crop for soiling and fodder uses is very great, and as a fertilizing crop peas are excelled only by clover.

There is no kind of live stock on the farm to which peas can not be fed with positive advantage when they are to be had at prices not too high. They are not commonly fed to horses, since they can seldom be spared for such a use, but they make a good food for horses at work, and colts during the period of development, if given as a part of the grain food. As a food for fattening cattle, peas are probably unexcelled. Much of the success which Canadian feeders have achieved in preparing cattle for the block has arisen from the free use of peas in the diet. During the first part of the finishing period they will be found peculiarly helpful in making beef, owing to their relative richness in protein, but they are also a satisfactory food at any stage of the fattening process. During the first half of the finishing period peas will be found superior to corn, but toward the close of the same corn could probably be fed with greater relative advantage. Peas with oats or wheat bran make an excellent grain food for cattle that are being fattened. Speaking in a general way, peas should form about one-third, by weight, of the meal fed, but, as every feeder knows, the relative proportions of the meal used should vary somewhat as the season of fattening progresses.

Peas furnish a good food for milch cows. They have been found peculiarly beneficial for building up dairy cows when "out of condition," and for sustaining them in fine form, and they are also excellent for milk production. When given along with oats and bran to cows in milk, they may usually form from one-third to one-half of the grain portion by weight.

Peas, when fed with judgment and care, supply an excellent food for swine at all stages of development. They are well adapted to the sustenance of brood sows during the nursing period, for the reasons that have been given for their use with cows giving milk. With shorts, ground oats, or wheat bran, they may be made to form one-third to one-half the grain portion. Peas are superior to corn as a food for pigs at any time prior to the fattening season; hence they may be fed to them more freely, but in no instance should they form the sole ration before the finishing period begins. During the fattening period peas are unexcelled when fed as the sole grain food. They promote growth, while they fatten in excellent form, and they furnish a sweet, firm, and excellent quality of pork.

Along with oats, in, say, equal parts, by weight, peas make good grain ration for ewes in milk, and also lambs, more especially when the latter are for the early market. They may be used in greater proportion to fatten ewes quickly after the lambs have been weaned. When sheep are being fattened for the block in winter, no grain food can be fed which will be found more suitable than peas and oats. When fed to sheep or poultry, or to brood sows in winter, peas do not require to be ground. For all other live stock it is considered advantageous to grind them, but in some instances they are soaked for

feeding to swine. When so prepared, they are frequently fed to growing swine when on pasture, and in order to insure due mastication they should be fed on a floor.

When pea straw is well cured, it is more relished by horses, cattle, and sheep than the straw of rye, wheat, barley, or even oats. Animals which have never eaten it may not take kindly to it at first, but soon learn to eat it with a relish. The value of the straw, however, depends largely upon the stage at which the crop is harvested, the mode of harvesting, and the perfection of the curing process. Pea straw harvested rather under than over ripe, and then properly cured, will be eaten readily, but when allowed to get dead ripe, live stock will eat little of it unless compelled to do so by hunger. If harvested with the old-fashioned revolving horserake, so much of the soil adheres to the straw that it is not relished by any class of live stock; and when rain falls upon the straw while it is curing, it becomes bleached and loses much in palatability. Two or three smart showers falling upon pea straw greatly injure it. When cut with the scythe or the pea harvester, cured properly, and then housed or carefully stacked, the straw, except that of some of the coarsest varieties, is nearly equal to clover hay in feeding value, especially for sheep.

Peas are more commonly used as a pasture when sown in conjunction with some other kind of grain, and since they are more easily injured by the trampling of live stock than other grain crops, it is usual to pasture them only with sheep and swine. When sown with oats or barley, peas make a good summer pasture for sheep. The greatest objection to such pasture is in the earliness of the season at which it is produced. Of course, it may be grown later, but will not produce so abundantly. One-fourth of an acre grown at the Minnesota Agricultural Experiment Station in the spring of 1895, under the supervision of the writer, furnished pasture sufficient for one sheep for 345¾ days. The pasture was eaten down three times successively, with a suitable interval between each season of pasturing. The plat was then sown with rape, and this in turn was pastured off. The great value of peas as a pasture for swine is far too little understood.

Peas grown in conjunction with some other kinds of grain are of great value as a soiling crop, owing, first, to the larger yields obtained (from 10 to 20 tons per acre may be expected on average soils); second, to the high nutritive value of the food, combined with its palatability; and third, because of its timeliness. This crop is ready as soon as the spring grasses begin to fail, and it may be made to continue in season until corn is ready. It is excellent for all kinds of live stock, but especially valuable for dairy cows.

The advantages resulting from growing peas in conjunction with other grains for fodder are many. They include the following: First,

larger yields may be obtained from growing these mixtures than by growing the grains used in them singly, and the increased yield extends to the grain as well as to the straw; second, when fodder is thus grown it may be fed directly to the animals; it is not necessary, usually, to chaff it with the cutting box, and the labor and cost of first thrashing and grinding the grain are avoided; and third, a pasture crop, such as rape or rye, may follow the same season. Such a system will be found most helpful as an aid in destroying weeds. As the relative areas adapted to growing these foods far exceeds those adapted to growing peas for the grain, it is probable that in the near future they will be most extensively grown for soiling and fodder uses.

Like all leguminous crops, peas have the power of extracting nitrogen from the air and of depositing it in the soil for the use of other crops which follow. Hence it is that the soil on which a crop of peas has been harvested is richer in nitrogen than before the peas were sown upon it. In this we have one explanation of the practice which became general in Ontario, of following peas with winter wheat. Peas could thus be made to bring more nitrogen to the soils of this country every year than is now purchased annually by the farmers at a cost of millions of dollars.

WHY THE PEA CROP HAS BEEN NEGLECTED.

That so valuable a crop should not have received more attention is indeed surprising. Chief among the reasons why it has been so neglected are the following: The lack of knowledge as to its merits, the difficulty in procuring seed, the want of suitable machinery for harvesting the crop, and the small measure of attention given to it, relatively, by the experiment stations. But little is known of the value of the pea crop by the average farmer.

The scarcity and costliness of seed have hindered many from growing peas. The average prices paid to seedsmen in the United States during recent years for good, clean seed have been from $1 to $1.25 per bushel. The Ontario farmer usually raises his own seed or buys it for about 1 cent per pound. Suppose a farmer should buy but 1 bushel of seed and sow it with care: he may expect in the autumn 10 bushels of seed wherever the conditions are favorable to growing the crop. Why should not farmers generally raise their own seed peas?

The lack of suitable machinery for harvesting peas has probably more than anything else hindered the extension of their growth in the United States. Where peas have to be harvested with the scythe, they are not likely to be grown to any considerable extent; but, as shown elsewhere, pea harvesters are now in use in Ontario which will cut a field of peas as quickly as a field of hay of equal area could be cut.

Very little attention has been given to this crop by the experiment stations of the continent. But little that can be regarded as of much value to the farmer is to be gleaned from the reports. The Ontario station, at Guelph, is an exception. The writer, when in charge of that station, imported many varieties from Europe and other countries for experimental uses, and the cooperative experiments with the best of these varieties, which have since that time been carried on by the farmers in various parts of Ontario, have been of great value in determining the most suitable kinds for the different sections of the country. Here is a field for experimentation in which the several stations, more especially those of the North, can render most valuable service to the States in which they are located.

AREAS ADAPTED TO PEA CULTURE IN THE UNITED STATES.

Without any doubt there are vast areas in our favored country well adapted to growing peas as a grain crop. But the areas in which the crop can be grown for pasture, for soiling uses, and for fodder are vastly greater, as heretofore intimated; for where they can be successfully grown as a grain crop they can also be grown for the other uses named. In the present state of our knowledge it would be impossible to name exactly all the areas in which peas can be successfully grown for any of the uses mentioned, and it would be even more hazardous to specify where they can not be grown. But these areas may be defined in a general way.

Peas can be successfully grown as a grain crop throughout New England. They are successfully grown in northern Michigan, northern and eastern Wisconsin, and northern Minnesota. They will also grow well in North Dakota, Montana, Idaho, Oregon, and Washington. In northern Ohio, southern Michigan, southern Wisconsin, and southern Minnesota they are not so sure a crop as in the areas named, but sometimes they produce well.

Southward from the States just named peas can not always be depended on to yield well. The summer temperatures are too warm for them. Even though they should produce a good crop of straw, if a hot wave should pass over them while in bloom, they would not fruit well. But in all this section of country great use can be made of peas when grown with other crops for pasture, for summer feeding, and for fodder. Still farther to the south the wisdom of giving much attention to this crop is open to question; the Southern cowpea has taken its place there.

GROWING PEAS FOR DIFFERENT PURPOSES.

In discussing the growing of peas as a grain crop, problems relating to soils, rotation, tillage, seed, varieties, harvesting, storing, and thrashing require to be considered.

Adaptability in soils.—Peas may be grown successfully on a variety of soils, but those designated clay loams, and which are well supplied with lime, are best adapted to their growth. However, good crops may be obtained on the stiffest clays. The potash element in these favors the growth of peas. Light, leachy sands, being deficient in moisture, do not produce enough of growth of vine, and black humus soils produce too much. Overwet soils are wholly unsuited to the growth of peas.

Place in the rotation.—Theoretically, peas should not come after meadow or pasture, since they are capable of gathering nitrogen from the atmosphere, and in consequence do not need the sustenance furnished in the decay of grass roots so much as other grains; but in practice they serve the end of quickly subduing such soils by promoting the rapid decay of the sod and so putting the land in excellent condition for the crop which follows. Peas may be assigned any place in the rotation, but the aim should be to have a grain crop follow which is hungry for nitrogen.

Preparing the land.—In climates where peas can be grown at their best, namely, climates with low winter temperatures, the land for peas, as for nearly all grain crops, should be plowed in the autumn; but peas will do better than the cereals, relatively, on spring-plowed land. A fine pulverization of the soil is advantageous, but it is not so necessary for peas as for other grain crops, since the pea is a hardy and vigorous grower.

Sowing the seed.—Some writers advocate sowing the seed broadcast and then plowing it under. On heavy soils this method would bury the seed too deeply. On prairie soils it promotes the rapid evaporation of soil moisture. On fall-plowed lands the better plan is to prepare the seed bed by pulverizing it and then to sow the seed with the grain drill. When broadcasted and covered with the harrow only and rain follows, much of the seed will be exposed; but the writer has grown excellent crops on spring-plowed stiff clays from hand sowing without any previous pulverization. When such lands are carefully plowed, the peas fall in the depression between the furrow slices, and the subsequent harrowing covers them. Peas should be buried less deeply on stiff clays and more deeply on the soils of the prairie. The depth may be varied from 2 to 4 inches. The pea crop should be sown as soon as the soil can be worked freely; but it will suffer less, relatively, than the other grain crops if the sowing has to be deferred. In sections where the pea weevil (*Bruchus pisi*) is prone to injure the crop, late sowing will shield the same from harm, but there remains the danger of loss from mildew.

The quantity of seed required will vary with the character and condition of the soil and with the variety of seed sown. Rich and moist soils do not require so much seed as where the opposite conditions prevail. The amount of the seed sown should usually increase with

the size of the pea. The quantities to sow per acre will vary from 2 bushels with the smaller varieties to 3½ bushels of the larger sorts. One great difficulty to be encountered in growing peas on prairie soils is the usual luxuriance of weed life, but this may be held in check by harrowing the crop before it appears above the surface. Harrows with teeth which may be set aslant are the most suitable for the work.

Varieties to sow.—The most suitable varieties of peas to sow will depend somewhat on soil and climatic conditions; and the best way, probably, to determine which kinds are best suited to the varied conditions of each State would be through experimentation on what may be termed the cooperative plan, as practiced in Ontario. This plan in outline is as follows: The station furnishes the seed of a number of proved varieties to farmers in different sections of the country. These varieties are to be grown under similar conditions, and they are also to report the results to the station at a given date. The results are then summarized and made public. The farmer keeps the grain which he grows as his compensation.

Several varieties were thus tested in Ontario in 1894. The three which stood first in point of yield were the Prussian Blue, Canadian Beauty, and Tall White Marrowfat. The respective average yields were 27.9, 27.1, and 26.8 bushels per acre. The yields of straw were not far different, nor was there much difference in the average time of maturing. The Prussian Blue is one of the most hardy, prolific, and reliable sorts grown in Ontario. The peas are blue in color and they weigh well. This variety also gave the largest average yields in the cooperative experiments of 1895. The Canadian Beauty is a handsome pea, white in color, and somewhat large in size. The Tall White Marrowfat is of large size and it is a vigorous grower. The four best yielding varieties grown at the Ontario experiment station for four years ending with 1894 are the Early Britain, White Wonder, Mummy, and Prussian Blue. The average yields were very similar. The Early Britain, imported from England in 1889, has proved a uniformly good yielder, but the peas are a little brownish in color and somewhat irregular in shape. The White Wonder, imported from New Zealand in 1890, is a very promising variety. It is a free grower, a good yielder, and the pea itself is attractive in appearance. The Mummy, a well-established variety, is a strong grower, but the straw is coarse. The pods are much prone to cluster about the top of the vines. Among the other useful varieties grown at the Ontario station are the Centennial White, Cleveland Advancer, and the Golden Vine. The last named is an old standby. When farmers speak of "Canada peas" they have reference probably to this variety more often than to any other. All the varieties named should do at least fairly well in the New England States, and in northern Michigan and Wisconsin. Through the various States of the Northwest the

following varieties stand high in favor with the farmer, namely, the Chancellor, the White Marrowfat, and the Black-Eyed Marrowfat. The Chancellor is an early and productive variety.

Harvesting the crop.—Until recent years the pea crop was harvested with the scythe or with the old-fashioned revolving hayrake. The first method is slow; the second shells out many of the peas, and it so covers the vines with soil as to render the straw practically unfit for use. Happily a pea harvester has been introduced by the aid of

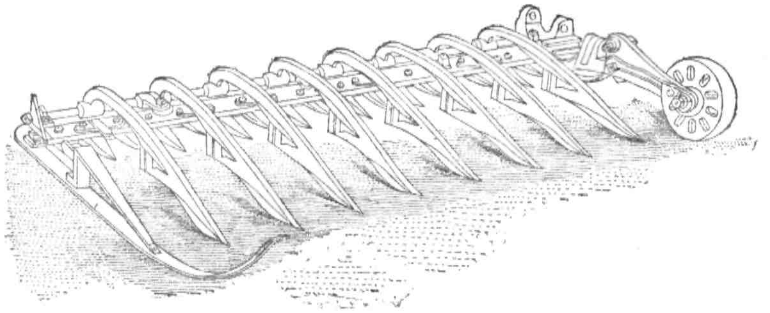

FIG. 46.—Pea harvester.

which the crop may be harvested speedily and in excellent condition on level soils. It is simply an attachment to an ordinary field mower, as shown in fig. 46.

The guards in front lift up the peas so that the knife can cut them cleanly. The cut peas fall behind the mower in a string-like row, or swath, and two men with forks bunch them and lay them aside out of the way of the horses. Three men and a span of horses may thus

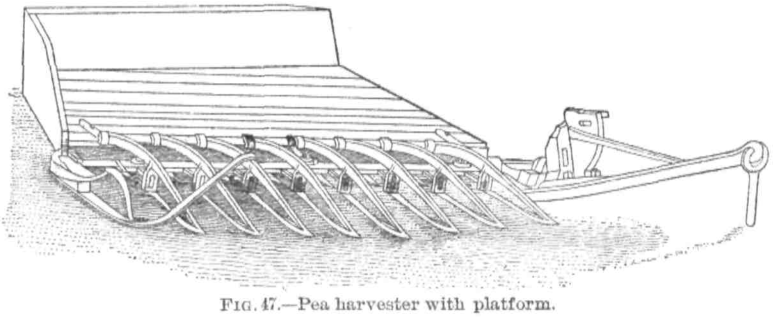

FIG. 47.—Pea harvester with platform.

harvest 10 acres in a day. This attachment for harvesting peas is made in Canada, and those now in use in the West have all been imported. On rear-cut mowers a platform is sometimes used, as shown in fig. 47.

With this attachment, one man walks behind and with a fork throws the peas off in bunches. But the platform is of doubtful advantage unless the crop is evenly ripened, not too heavy, and free from standing weeds of strong growth. Where the land has been

plowed in ridges, with furrows more or less deep between them, the working of the machine will be seriously interfered with.

Storing the crop.—It is usual to turn the bundles over once to facilitate drying while they lie on the ground. They require hand loading. The crop may be stored under cover or put into stacks, as with other grain, but it should be borne in mind that peas when in the stack do not readily shed rain, and therefore the stacks should be carefully topped out with some substance, such as blue grass or native prairie hay. When the thrashed straw is preserved in stacks the same precautions are necessary.

Thrashing the crop.—Where only a small quantity is grown annually, and this with a view to provide seed to sow for pasture, soiling, or fodder uses, there is no better way of thrashing the peas than by using a flail or by treading them out with horses. The seed is not then broken. Where a large acreage is grown, it is necessary to thrash peas with a thrashing machine, and the best work is done by using the "bar concave," as shown in fig. 48.

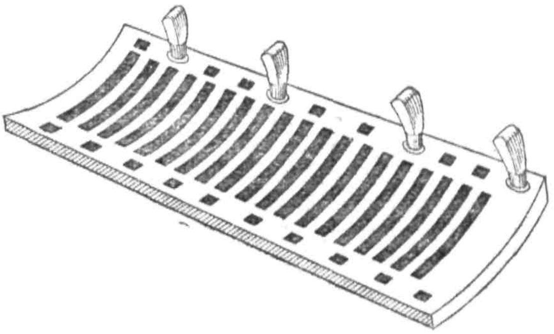

FIG. 48.—Single concave thrashing machine with four teeth.

From this concave all the teeth should be removed except four. These hold the straw in check long enough to enable the cylinder teeth to beat out all the peas. The machine should not run at a high rate of speed. More or less of the seed is likely to be broken. The broken grains, however, may be nearly all removed when preparing the crop for seed or for market by using fanning mills suitably equipped with sieves. When the crop is wanted for feeding uses, the breaking of the peas does not, of course, lessen its value.

The great value of peas for various uses has already been dwelt upon. It only remains, therefore, to speak of the methods by which they are grown.

When peas are grown in conjunction with other grain for pasture, the mixture should be sown somewhat thickly. For sheep 1 bushel of peas may be taken as the basis of the mixture, and from $1\frac{1}{2}$ to 2 bushels of other grain. When seed drills are used, the seed should be mixed before it is sown. Under other conditions it would be necessary to plow the peas in lightly, and then sow the other grain and cover it with a harrow. Peas and oats or peas and barley may be grown as a pasture for swine in the same manner as for sheep, but it is generally thought better to reduce the proportion of peas when the pasturing is to begin at an early stage in the growth of the plants, as swine break down the pea vines to a greater extent than

Since it is profitable in the West to apply water to the full amount required by crops, it will certainly pay in humid sections to supplement an occasional deficiency to the extent of from 2 to 5 inches.

If it is desirable to use water with profit for garden crops, a source for the supply should first be fixed upon, and while it must be a supply that will furnish the required amount in a time of most severe drought, the cheapness with which the water can be brought upon the land should also have consideration.

In some locations water can be obtained from town or city waterworks, and, unless a very large quantity is required, it will often be cheaper than to put in an independent pumping plant. Artesian wells or never-failing springs afford a cheap source of water, especially if the water can be carried to the land by gravity. Lakes or streams from which the water may be conducted upon the land can occasionally be found, and, if sufficiently near, will form an extremely cheap source for water supply. As a rule, however, even if the water is available, it is below the land and some method of raising it must be employed, so that the cost of pumping machinery will need to be considered. Driven wells can generally be relied upon in the absence of any of the above sources of water supply. They are in successful use for this purpose in many places, the water in some cases being obtained within a few feet of the surface and in others at a depth of 100 feet. Where the wells need not be more than 60 feet deep, and where the water stands within 40 or 50 feet of the surface, the cost of raising it will not be excessive. If one well does not supply the desired amount, several may be driven and attached to the cylinder of one pump.

POWER AND MACHINERY.

For irrigating purposes the pumping apparatus must be of such a nature that it will raise the large amount of water required at a small expense, and at the same time be strong and durable.

Some of the hydraulic rams comply with the above conditions. They work automatically and without expense, being driven by the force of the water. Where a suitable water supply and a sufficient fall can be secured, enough water can be thus elevated for a considerble area if a reservoir for its storage is provided. If running water is at hand and the lift is not great, some form of water wheel which is arranged either for lifting the water directly or for operating some special pumping machinery may be used. The endless-chain-and-bucket machinery also answers well for small lifts. The hot-air pumping engines are also adapted to this work upon small farms. They are cheaply operated, requiring but little attention or fuel, are perfectly safe, and will handle from 100 to 1,000 gallons of water per hour, according to the distance it has to be lifted and the size of the engine. When the water does not have to be raised over 50 feet, the centrifugal pumps may be used with excellent results. They are

comparatively cheap, quite durable, and may be obtained of a capacity to handle any desired quantity of water. While lifting pumps require the water to be quite clean, there is less necessity of it in the case of the centrifugals. The rotary pumps have a similar use.

Of the lifting pumps there is a great variety, but some of the forms with large cylinders, commonly called irrigation pumps, should be used. They answer well where but a comparatively small amount of water is required and where it has to be drawn from a considerable depth. For very large pumping plants some of the direct-acting steam pumps have been used and they supply the water at a low cost.

In a few cases the pumps mentioned above require no outside power, but in the centrifugal and lifting pumps some motive power is necessary.

The windmill is generally regarded as the cheapest power for light work where regularity is not essential, and is largely used. The modern galvanized steel mills, upon steel towers, are quite durable, and, provided they are double geared, will run in very light winds. In sections where the wind has a velocity of 8 or more miles per hour, for an average of at least eight hours per day during the summer months, they furnish a cheap source of power for irrigating gardens of from 1 to 3 or perhaps 5 acres in proportion to the distance the water is lifted. They are used principally with lifting pumps. From the fact that the working of the mill is likely to be intermittent, a storage reservoir is necessary in connection with such a plant.

Gasoline engines have an advantage over steam in that they do not require regular attention, are perfectly safe, and are less expensive to run. For small pumping plants and up to 10 or 15 horsepower they will be found well adapted. While steam engines will not be desirable ordinarily, except perhaps for supplying water for large areas, or when needed for other purposes, there are conditions that would favor their use. For fruit and most other crops it is seldom that more than two or three applications are necessary in a season, and it will be cheaper in most cases to hire a portable engine for the few days it will be needed than to buy an engine of any kind. In all of the Western States, traction thrashing engines may be readily obtained, at a small rental, as they usually stand idle except during the thrashing season.

DISTRIBUTION.

The method by which water will be carried upon the land will depend largely upon the surroundings. If there is a large amount of water and an easy grade can be secured, it may be carried in open ditches, which can be easily excavated with a plow and scraper. Vitrified sewer pipe may be used if the ground is uneven, but will not be desirable if there is over 10 or 15 pounds pressure. Where the distance is not great, or if the pressure is considerable, particularly if the water is pumped, riveted sheet-iron tubing or steel gas pipe can be used. These are readily put together and taken apart

as desired, and gates and water plugs may be attached at will. If arrangements are made to drain the pipes, or if they are taken up in winter, they may be placed upon or near the surface.

The size of the pipes needed will depend upon circumstances. For tracts of from 5 to 10 acres a sewer pipe 4 inches in diameter is desirable, although a 3-inch pipe would answer if there is a fair fall. When using iron pipe, the size of the distributing pipes, upon tracts of a half acre or over, should be 2 or, better, 2½ inches. For the main supply pipe from the pump or reservoir a somewhat larger size will lessen the friction and increase the capacity of the system, but if the distance is considerable it will cause a large outlay, and it might be cheaper in the end to use a smaller size and take a little more time. While a 4-inch pipe would be desirable, a 3-inch one would answer for from 20 to 100 acres. The branch pipes in small gardens may be as small as 1 inch, although a larger size is desirable. Wooden or sheet-iron flumes may also be used for carrying the water.

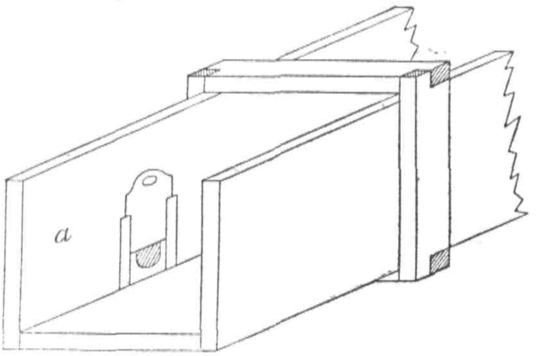

FIG. 49.—Square trough for distributing water (section). *a*, sliding zinc on galvanized iron gate.

The supply pipe or ditch should take the water to the highest point of the tract to be irrigated, and, if the land is uneven, with several knolls, a branch pipe should be carried to each of them. If there is one point from which the water will flow over all others, it can be distributed from that point in flumes or ditches to the furrows and thus spread over the land. While this will lessen the expense if pipes are used, it will be better not to attempt to water more than 1 or 2 acres from a single hydrant. If applied from a hose, it is not desirable to have the hydrants more than 200 feet apart, requiring a hose 100 feet long. For a tract not over 200 feet wide and from 300 to 500 feet long, measuring down the slope, a single hydrant at the middle of the upper side will be sufficient. A regular hydrant can be constructed if desired, but if there is a T with a gate valve at the point where the hose is to be attached, it will answer every purpose.

One of the best methods of distributing the water from the hydrants is by the use of wooden troughs (fig. 49). They may be put up permanently along the head of the rows, or may be made portable in sections of 16 feet. They should be from 6 to 8 inches square inside, or 8 inches deep if triangular. Along one side, at intervals of from 3 to 20 feet, according to the crop for which they are to be used, there should be holes from 1½ to 2 inches in diameter, closed by zinc or galvanized sheet-iron gates (fig. 50). The troughs should stand nearly

level. If the land slopes there should be an occasional drop in them. To control the flow of the water wooden sliding gates are desirable at frequent intervals and at the end of each section of trough. By means of the small gates the water can be distributed to a number of rows at a time and the flow can be regulated at will. A 2½-inch distributing pipe under a fair head will supply from 6 to 10 rows, using full-sized openings, while if they are only half open from 10 to 20 rows can be watered that are from 150 to 400 feet in length, according to the character of the soil. If the gates are 3 feet apart this will supply water for one-eighth to one-half an acre, and will require, to properly water this area, from one to three hours, reckoning upon a flow of 100 gallons per minute and an application of from 900 to 1,000 gallons per acre, or a little more than enough to cover it to the depth of 1 inch.[1]

When a sufficient amount of water has been applied to any of the rows, the gate can be closed and another opened. In a small garden a similar but smaller trough can be employed to good effect, but not over one or two gates can be used at one time from a three-fourths-inch hydrant, or two or three from a 1-inch hydrant.

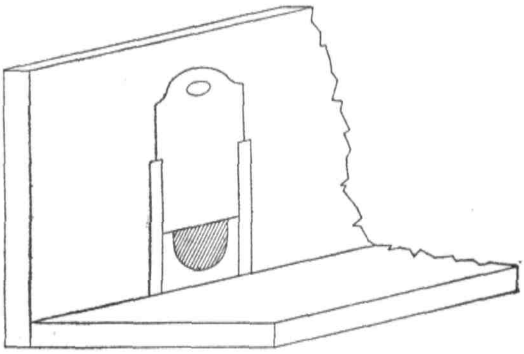

FIG. 50.—V-shaped trough (section).

Instead of the trough an iron pipe can be run along the head rows and the water applied through small faucets placed at proper intervals.

If neither troughs nor pipes are used, an open ditch can be run along the head row and this will serve the same purpose. If ditches are used, it is desirable that small wooden boxes, closed at one end with a sliding gate, be placed at points where the water is to be drawn out, but the water is often applied by making openings in the bank through which it can be drawn.

RESERVOIRS AND TANKS.

For properly irrigating tracts of much size, a large amount of water should be available, in order that it may be turned upon the land in

[1]It requires 27,154 gallons, or about 850 barrels, to give an inch of water over an acre. The miner's inch, used in the West as a unit of measurement, is the amount that will flow per minute through an opening 1 inch square with a head of 4 inches—about 9 gallons. A cubic foot of water per second-foot, which is also used as a measure for water, represents a flow of about 50 miner's inches, or 450 gallons, per minute.

considerable quantities; and unless the pumping apparatus will supply a steady stream of 100 to 200 gallons per minute; a reservoir or tank is desirable, except in small gardens. While iron or wooden tanks will be best for small amounts of water, basins can be made for large areas by throwing up embankments of soil, and rendering them water-tight by means of cement, tar, or clay. In most parts of the country care is necessary to keep the cement and tar from cracking in winter; clay will answer nearly if not quite as well. The reservoir should be located upon the highest point of ground near the land to be irrigated. The bottom of the reservoir should be as little as possible below the surface, in order that a fall may be secured, and the walls should not be more than 5 or 6 feet high, with a slope of about 20 degrees. The top of the embankment should be from 2 to 4 feet wide, according to the size of the reservoir. If the soil is not of rather stiff clay, it should be covered to the depth of 3 or 4 inches with clay, and after this has been worked until it is fine, water should be admitted sufficient to form a thick mortar, when it should be thoroughly puddled over the bottom and sides. The water should be drawn out from the reservoir through an iron pipe laid at the bottom of the embankment, this to be provided with a valve by which the flow of the water can be regulated; and to prevent the water of the reservoir from soaking out along the sides of the pipe, it should be laid in grout where it passes through the embankment into the reservoir. Unless the reservoir is filled with water during the winter it will require puddling every spring.

APPLYING THE WATER.

Having the water upon the land, it can be applied in various ways. Flooding, or allowing the water to spread over the surface to the depth of from 2 to 10 inches, was formerly extensively used, but it is now employed only for grain and similar crops. The most common method for vegetables and fruits is to make furrows and run the water along in them, so that it can soak into the soil. If properly arranged, the water can not spread upon the surface, and, by turning back the furrows as soon as the water has soaked in and cultivating the soil, the moisture can be prevented from evaporating. For large areas, a shovel plow is the best tool for making the furrows, although if the soil is loose a man with a hand plow can do as good work, while a hoe or shovel will answer in small gardens.

Care should be taken to so lay out the rows in the orchard or garden that the furrows for the water can be run at a very slight slope, 2 or 3 inches in 100 feet being all that is desirable, while 1 foot in 100 feet is an extreme slope. With a little care in laying out the furrows water can be used upon land that, at first sight, it will seem impossible to irrigate. If there are slight irregularities in the surface that can be scraped off without materially injuring the land, it will be best to remove them. When the land is rolling, basins or checks may be used, especially in orchards.

Subirrigation is the term applied to the running of water through pipes laid below the surface of the ground and allowing it to soak out through cracks or holes made for the purpose. The pipes are generally common drain tiles, from 2½ to 4 inches in diameter, laid at depths of from a few inches to 2 or 3 feet. Particularly upon muck or swampy land, if they are placed at a considerable depth, they will do good service as drains, besides distributing water in dry seasons. By having the ends of the lines of tile open into a ditch, the water can be carried off when there is a surplus, while, by damming the ditch and filling it with water, the tiles will carry it back for several hundred feet and moisten a space upon either side of from 15 to 40 feet. They should be placed 12 inches deep, in garden loam soil at a distance of 12 or 15 feet apart, but in very light sand or stiff clay shorter intervals will be advisable. The tiles should have a very slight slope, for if there is much head the water will break out unless they are laid at a considerable depth. Several lines may be joined to a larger line laid across their ends, although if each line of tile is supplied independently, a more even distribution will be obtained. While it will vary considerably with the soil, a half-inch stream will suffice for 100, a three-fourths-inch for 200, a 1-inch for 400, and a 1½-inch for 1,000 linear feet of tile.

In laying the tiles a small opening should be left between them at the lower side, and this will allow the water to pass out freely without admitting the soil. Under ordinary circumstances there will be no trouble from the clogging of the tiles with roots.

It is claimed for this method of watering that it requires less water and that after the tile is in place less attention is necessary. Upon a small garden where the water supply is small, or if it is delivered in small pipes, this method of watering is of value, as the water needs only to be turned on and it will distribute itself without further attention.

While there is a saving of labor in distributing the water, the cost of tiles and the expense of laying them makes this method much more expensive than furrow irrigation. Except as mentioned above, subirrigation has few, if any, advantages over furrows for fruits and the ordinary garden crops. As water can be applied in furrows for fruits or large areas of vegetables at from 50 cents to $1.50 per acre, according to the crop and the amount of water available, one can not afford to go to the expense of fitting the land for subirrigation, except where the tiles are needed as drains.

For flower beds and lawns, where water can not be applied in furrows, tiles can often be used to good advantage. Placed at the depth of 1 foot and as nearly level as possible, they will distribute the water quite evenly over a space from 8 to 16 feet in width. For short lengths the flow of the water should be restricted to the amount that can be given off by the tiles.

Great injury is often done by the drying out of the trees in winter, and if the autumn is very dry it will be well to irrigate the trees just before the ground freezes. The amount of water required by orchards is from 1 to 2 inches at each application, while the frequency of watering must depend upon conditions. When a loam soil taken from a depth of 5 or 6 inches will not pack in the hand, it is an indication that water is needed. Ordinarily once in from two to three weeks is as often as water need be applied. While a fair amount of water will increase the size and improve the quality and appearance of the fruit, an excess will lessen the size and injure the quality.

Basins or checks can often be used to advantage when the ground is uneven or sloping. They are formed by scraping the soil away so as to form ring-like depressions about the trees, into which the water is turned. They should have a diameter equal to that of the branches, and the amount of water used should be sufficient to cover the area occupied by the roots to the depth of at least an inch.

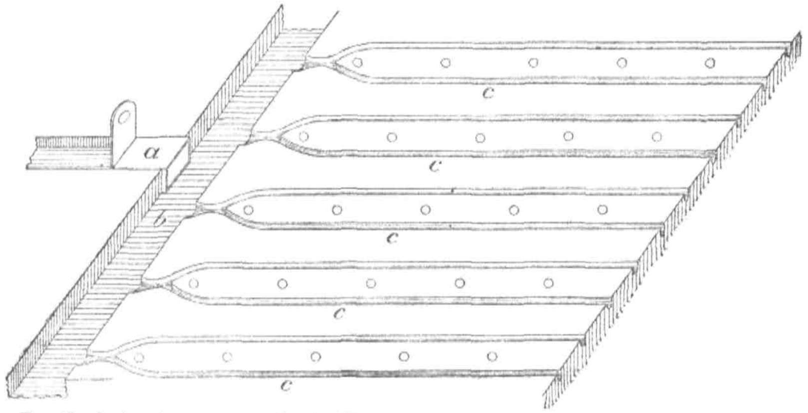

FIG. 51.—Irrigating young orchard with furrows. *a*, sluice; *b*, head ditch; *c*, furrows.

Where water is not at hand for irrigating, good results can often be obtained by hauling it in tanks or barrels and running it into the basins, using from 1 to 2 barrels for each peach, pear, or plum tree from 5 to 10 years old. As soon as the water has soaked in, the dry soil should be replaced to prevent evaporation.

The method of watering strawberries and other small fruits is not unlike that used for vegetables. The water is run down the center of the rows in furrows, or, better yet, close alongside the rows. If the ground is very dry in the spring, a good watering may then be given, but after growth has started *no water should be given until the fruit has set*, after which the irrigation may be kept up as needed at intervals of two or three weeks until the fruit is gathered. All except the grape may need an occasional application after that time, and if the ground is dry as winter comes on an application at that time is desirable.

COST OF IRRIGATING.

The expense of an irrigating plant and the cost of operating it will depend upon the distance the water has to be raised and carried to get it upon the land, as well as the method of moving it. A windmill, with pump, well, and reservoir, suitable for from 3 to 5 acres, should not cost more than from $300 to $500, if the water does not have to be raised more than 40 feet, and there would be comparatively little expense for operating it. A pumping plant, operated by a steam or gasoline engine, suitable for 20 acres and capable of supplying 50 or 60 acres, would cost perhaps $1,000. The cost of fuel for the latter would perhaps be 15 cents per acre for elevating the water required for one application, reckoning it at 1 cent per horsepower for each hour operated, while for the steam engine it would be about twice that amount. Using a steam engine and a centrifugal pump, water for one application for 10 acres can be raised 40 feet for about $4, including cost of attendance, and $5 will distribute it upon the land, making the cost, aside from the interest upon the investment, rather less than $1 per acre. With a gasoline engine it would be $1.50 for fuel and $5 for applying the water, or 65 cents per acre for each application.

PROFITS FROM IRRIGATING.

At the high estimate of $1,000 for a pumping system for 20 acres and of 10 per cent for interest and depreciation of machinery, irrigation is certainly a good investment for fruits and vegetables, as numberless instances could be given where the gains in a single season from the use of water repaid not only the expense of operating, but the entire cost of the plant. The expense for a steam pump is figured at 90 cents per acre, and with a gasoline engine at 65 cents, for each application. If water is used three times during the season, it will make the cost for an acre $2.70 and $1.95, respectively, for the two systems. Adding 10 per cent of the cost of the plant, or $5 per acre, it gives $7.70 for steam and $6.95 for gasoline engines as the entire cost of irrigating an acre of land three times in a season. When steam is used, it costs no more for attendance and but little more for fuel to pump the water for 10 acres per day than for 2, so that the cost for small areas would be slightly more, but $10 per acre would be a high estimate when the conditions are fairly favorable.

The irrigating system at the Michigan Agricultural College has the past summer given good illustrations of the benefits of irrigation in a dry season. It covers 10 acres of small fruits and vegetables, and has a 3-inch supply pipe from the river, with 2½-inch distributing pipes leading to hydrants at convenient points. The power is supplied from the regular pumping station, so that definite figures as to cost and expense of operating can not be given.

The crop of small fruits was greatly injured by frost, but where water was used no ill effects from the drought were observed, although the unirrigated sections were so dry that the crop was ruined.

Careful records were kept of the yield of the various vegetable crops, and the results from the use of water, as compared with unirrigated plats, showed a decided gain. In every instance the plats without water were given the advantage in soil and location, if there was a difference, and probably profited to some extent from seepage water.

The tomatoes and potatoes were irrigated four times, and the other crops received three applications of about 1 inch each.

The cabbage crop suffered most of all, perhaps, as where water was not used less than half formed heads of marketable size, and these were small. Of the Early Jersey Wakefield there were 5,000 more marketable heads per acre obtained by the use of water, and the weight was 11,325 pounds greater. The Henderson Early Summer showed a gain of 4,826 heads and 21,959 pounds in weight. At 2 cents per head the gain per acre would average nearly $100. A gain of 200 bushels per acre was obtained with the irrigated tomatoes, which at 25 cents per bushel would amount to $50, or five times the expense of applying the water. Snap beans showed a gain of 300 bushels, and early peas of 100 bushels per acre. Some of the potatoes were watered twice before blossoming, others twice after blossoming, and a third lot four times—twice before and twice after bossoming. The gain upon the latter was 129⅓ bushels; two early waterings gave a gain of 42⅓ bushels, and two late applications showed a gain of 50½ bushels over unirrigated plats.

Particularly in the case of peas, beans, and cabbages, the increase in the quality was nearly as marked as in the quantity.

Similar results have been obtained by several of the experiment stations, and in many instances market gardeners and fruit growers who have practiced irrigation have made an even better showing.

IRRIGATION FOR THE GREENHOUSE.

From the very nature of the case, plants grown under glass can not obtain a supply of water either from the clouds above or from the underlying soil, and if they are to maintain their growth it must be applied artificially. The common method of applying it through a hose or from a watering pot requires a man of experience and good judgment, as it is desirable to apply enough to moisten the soil without saturating it. Surface watering at the best packs the soil, thus preventing its proper aeration, promotes the development of slime and mosses upon its surface, and, particularly during the cloudy days of winter, keeps the surface of the soil in a damp condition, although the roots may be suffering from lack of water. In many cases, too, the water lodges in the axils of the lower leaves of the

plants, and by keeping them moist promotes the development of the spores of parasitic fungi.

To lessen the labor of watering greenhouses, various sprinkling arrangements have been tried. Some of these consist of sprinklers that can be moved from point to point in the houses, while others are arranged at intervals upon pipes so as to water considerable areas at one time. While some of these arrangements may be labor savers, they have all of the disadvantages of surface watering; while the fact that all parts of the house may not require the same amount of water, and that unless carefully watched a surplus of water is likely to be applied, renders them impracticable.

Greenhouse subirrigation.—During the past four years various methods of applying the water below the surface have been tried and for many crops have shown decided advantages over surface watering. The first attempt at greenhouse subirrigation was made under the direction of Prof. W. J. Green at the Ohio Experiment Station, in 1890–91, with the hope of preventing lettuce rot. The result upon the growth of the plants was so marked that it was repeated upon a larger scale and with a variety of plants. Similar experiments have been tried and the results published by the West Virginia and the Michigan experiment stations.

While applicable to pot plants, it is generally used for those planted out in beds. These may be raised benches made of wood, or of iron supports with tile or slate bottoms, or they may be what are termed solid beds, resting directly upon the soil. In either case they should be practically water-tight. With wooden benches it is desirable that the supports should be close enough to prevent the sagging of the boards. The bottoms were formerly made of clear, matched lumber, laid in white lead, but for several years ordinary barn boards free from loose knots have been used at the Michigan Station. If these are laid close together and firmly nailed to the stringers to prevent their humping, they will, when wet, swell sufficiently to close the cracks. The writer generally lays the boards across the beds upon stringers running lengthwise of the house. To close the remaining cracks and to preserve the lumber it is well to coat the inside of the bed with a cement made of one part of water lime and three of sharp sand. This should be made into a thick paste and spread over the surface about one-fourth of an inch thick. For a bed with tile or slate bottoms a similar covering will render them sufficiently tight (fig. 52).

In case a solid bed is used, a tight bottom about 8 inches below the intended level of the bed is necessary. If the subsoil is stiff clay, it may be puddled and will then hold water, but it will generally be better to spread an inch or so of gravel and, after thoroughly ramming it, to place over the surface three-fourths of an inch of cement prepared as above. The beds should have sides of the same material 3 inches high.

The best way of distributing the water is by means of 2½-inch drain tiles, placed either lengthwise or across the beds at intervals of 3 or 4 feet. If the line is not over 50 feet in length, they may be placed upon a level, but for greater lengths the line should have a slope of 1 or 2 inches in 50 feet. To learn if the water is circulating properly, it is well to make an opening into the tiles once in 20 feet, into which a small flowerpot can be set. In laying the tiles care should be taken that the cracks between them are of an even size. As a rule, it will be found that they have become slightly curved in baking, so that the ends are not square, and if the convex sides are placed uppermost there will be a small opening at the under side large enough to allow the water to escape freely. If thought desirable, several lines

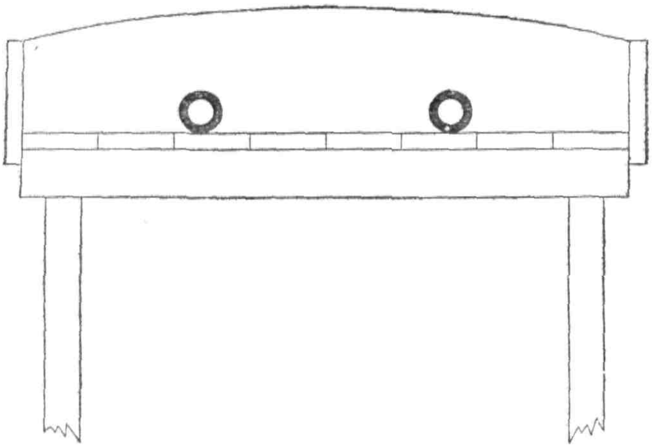

FIG. 52.—Water bench for greenhouse.

of tile can be so connected at one end that they may all be filled from one hose, or faucets may be arranged so as to supply water in any desired amount to the different lines. The water can be admitted through sewer-pipe elbows, or by raising the end of the last tile so that it will show above the surface.

One-inch gas pipes with one-fourth-inch holes every foot have also been tried at the Michigan Station. While good results were obtained, the openings frequently became clogged and the water was not given off as freely as when tiles were used, so that a longer time was required to water the beds. Besides being cheaper the use of tiles seems in every way preferable.

In a general way subirrigation in greenhouses shows about the same advantages over surface irrigation as are found in the garden, but while the saving in time of watering and in the amount of water required is even greater in proportion, the direct benefits, especially reduction of time (10–25 per cent) required for maturing, are of still more importance.

THE HEALTH OF PLANTS IN GREENHOUSES.

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The cultivation of plants in greenhouses, or, using the broader term, under glass, is rapidly assuming large proportions. In 1890 there were 4,659 establishments in the United States devoted to commercial flower growing. These represented a capital of over $30,000,000, and gave employment to nearly 20,000 men and women.[1] Eighty per cent of this business was developed in the twenty-five years prior to 1890; in fact, it may properly be said that commercial floriculture, as existing when the foregoing facts were collected, was practically a creation of the preceding quarter of a century. For the past five years the business has been growing fully as rapidly as during any similar period, so that there is probably now no less than $35,000,000 or $40,000,000 invested in this work. It must be remembered that this represents only the commercial floral business. When we take into consideration the capital invested in the growing of vegetables and fruits under glass, and that expended by amateurs and others not strictly engaged in commercial work, the aggregate sum invested will probably reach $50,000,000 or $60,000,000.

As this work has grown and as its importance has increased, the methods followed in the production of the various crops have undergone most radical changes. Up to a few years ago the plants grown in nearly all ordinary commercial greenhouses were of a mixed character. Roses, carnations, palms, and ferns might frequently be found in one house, where they were watched over and cared for by one or more men, without any systematic attempt at a division of labor, so far as the individual requirements of the plants were concerned. This practice was simply the result of the demands of the times, there being no occasion for a concentration of effort in any particular direction. All this has changed, however, within the past few years, for with the advent of different ideas the public has become more critical, and as a result specialization is now a marked feature of the business. With this feature becoming more and more prominent, competition is growing keener and keener, and greater energy must therefore be used in producing a crop that will not only hold its own, but will force its way to the front in the market. To accomplish this

[1] U. S. Census Bull., Floriculture in the United States.

necessitates a thorough knowledge of the requirements of each crop, how to keep each in perfect health, and how to manage the conditions so that the maximum of profit will be attained at the minimum of labor and expense. This knowledge can not be gained from books, but must be obtained by long experience and rigid attention to details. There are certain fundamental principles, however, which underlie all work of this kind, and a knowledge of these is often sufficient to make the difference between success and failure. It is of some of these principles that the writer proposes to speak, hoping that what is said will be of value to the ideal type of gardener—the man who can aid, guide, and advance his practical, intuitive skill by intelligence, foresight, and the ability to experiment and to profit by the work.

HEALTH AND DISEASE.

The growth of every plant is influenced by numerous factors—soil, heat, light, water, and air all having their effects. As the factors vary so does the plant in its habit of growth, in the quantity and quality of its fruit, leaves, or other parts, and in its ability to survive the influences which are constantly at work tending to destroy that which it has produced. The plant, in other words, is a constructive apparatus, governed by surrounding conditions over which it has no control, but to which it can adapt itself within certain limits.

If the conditions are properly regulated, an approximately ideal growth is attained. If, on the other hand, they are improperly furnished, the plant reacts to the influences and a departure from the ideal development is the result. This departure may be in the nature of a derangement of the functions of the plant and may result in sickness and death. The sickness may be simply due to a combination of influences acting on the vital forces of the plant, or it may be brought on by the presence of living organisms, as, for example, insects, fungi, etc. In the latter case the relation of the host, or the plant attacked, to the organism attacking it is exceedingly complicated, but it is not the purpose to enter upon a discussion of that question here. Suffice it to say that the more nearly the ideal conditions of growth are approached, the less likely is the plant to succumb to attacks of such organisms. On the other hand, the departure from the ideal growth may be in different directions; in fact, the remarkable susceptibility of a plant to surrounding influences, or, in other words, its plasticity, is seldom appreciated. For example, an American Beauty rose grown under certain conditions may give buds 3 inches in diameter, with stems 36 inches long. A cutting from the same plant grown under different conditions may give buds only 1 inch in diameter, with stems correspondingly short. In both cases the plants are healthy in the strict sense of the word, but the usefulness of one is so much affected by its size and other characteristics that it may properly be said to have no market value. So far, therefore, as

the commercial grower is concerned, such a plant as the one last mentioned is lacking in health, for to him health means the most profitable and remunerative development. It is in this sense that we shall discuss the subject, pointing out, from the standpoint of physiology, some of the more important factors which lead to the highest and best development of the crop.

THE SOIL.

One of the most important questions with everyone growing plants under glass is the soil, for upon a proper understanding of this depends in large measure success or failure in the work. While science has done a great deal to advance our knowledge of the relation of soils to the growth of plants, there yet remains much to be accomplished in the practical interpretation and application of the knowledge gained. The men to-day most familiar in a practical way with the requirements of different plants, so far as soils are concerned, are those actually engaged in agricultural and horticultural pursuits. By the appearance of the soil to the eye and by the way it feels when taken in the hand, a gardener can tell pretty accurately whether a certain soil will be suitable for a certain kind of crop. This knowledge is largely intuitive, and has been gained by long experience and close observation.

Speaking generally, it may be said that the perfect development of any plant, so far as the soil is concerned, depends upon two fundamental considerations: (1) The presence of the necessary amount of suitable food, and (2) the physical properties of the soil—that is, its texture and its relation to heat, air, and water.

That growth is dependent on the presence of proper food in the soil is now well understood, but how to supply this food so as to obtain the largest yields at the least expense is a problem of the utmost importance to everyone growing plants under glass for commercial purposes. As the work is now carried on, there are but few crops where it is practicable or desirable to add sufficient food at the start to carry the plant through the full season of growth. Feeding must be done through the entire growing period, and to do this properly is one of the most important problems with which the commercial grower has to deal.

The relation of the physical properties of the soil—texture, temperature, and moisture—to plant growth is not so well understood nor appreciated. It is obvious that these are not intimately connected with the chemical properties (food supply); in fact, it is a matter of common observation that the mere presence of an abundant supply of food is not sufficient to make a good crop, even though other conditions outside of the soil are to all intents and purposes perfect. This is well illustrated in the growing of roses, carnations, and other flowers. Certain varieties of roses and carnations may be grown to a high state of perfection in some sections, using, of course, proper

judgment and skill in the management of the conditions. In other sections, and they need not be remote, it is difficult to get a perfect crop, although the skill of the grower may be fully as great as in the former case, and the use of manure as food may have been fully as judiciously made. In such cases the texture and structure of the soil, which involve also the capacity of the latter for heat, moisture, air, etc., may be the basis of the trouble, and all these have a direct influence on food supply.

By texture is meant the character of the particles which make up a soil, while structure has to do with the arrangement of these particles and their relation to each other. The particles, or grains, of which soils are composed vary greatly in size, and to distinguish them they have received certain conventional names, such as clay, fine silt, silt, fine sand, sand, etc. The clay particles are extremely minute, silt grains are larger, and so on until we have coarse sand or gravel, with grains 2 mm. in diameter.[1]

Upon the amounts of the various constituents present, i. e., clay, fine silt, silt, fine sand, etc., will depend the porosity of the soil, the readiness with which air penetrates it and water moves through it, its water-holding capacity, and, finally, its temperature.[2]

It will be seen, therefore, that the texture and structure of a soil have an important bearing on the development of the plant, affecting not only the growth of the roots, leaves, stems, and flowers, but the relative proportion of these and their relation to each other.

By varying the texture of a soil, its water content is varied, its capacity for heat is modified, and so on, until every important factor, including food, in the ordinary acceptance of the word, is involved. To these variations the plant adapts itself, and the result may be excessive leaf development, with few or no flowers, or vice versa; a weakened condition of the tissues, making the plant subject to the attacks of parasitic enemies, especially fungi, and so on through a list of other possibilities. To illustrate, we may have a rose grown in a soil of a certain texture and structure. The water capacity of this soil is most favorable for growth, and may be represented by 10. The capacity for heat, permeability to air, and the readiness with which water moves through it are also ideal, and may each be represented by 10. These conditions may so act on the food in the soil as to place it at the disposal of the plant in the most suitable form, so that food supply may also be represented by 10. Suppose, now, the texture of the soil is modified by the addition of clay: the water content of the soil is changed, this in turn affects the access of air and also the temperature, and the food supply is involved by the effects of the different changes on certain soil organisms, which play an important part in the matter of food. As a result of these various

[1] Whitney, Bull. No. 4, Weather Bureau, U. S. Department of Agriculture.
[2] Wollny, Experiment Station Record, 1893, Vol. IV, p. 529.

combinations and changes, we may have the water capacity of the soil represented by 12; capacity for heat, permeability to air, readiness with which water moves, 8; food supply, 8, etc. It will thus be seen that the plant in this case has an entirely different set of factors to which it must adapt itself, and in doing this it may so modify its development as to become unprofitable; that is, the new set of factors may give a good leaf development at the expense of flowers, or if a certain leaf development is wanted, as in the case of plants like lettuce, the color and texture may be changed to such an extent as to make the crop unprofitable.

It will, of course, be recognized that in the growth of plants under glass the conditions surrounding them are under far better control than those outside. Hence the gardener who grows plants in greenhouses has a wider range in the use of soils than he who grows them outside, for if the texture is not exactly suited to the requirements of his plants, he may partly overcome the difficulty by the judicious use of water and rigid attention to other conditions. There is a limit, however, beyond which even he can not go, and the nearer he approaches this limit the more care he must exercise in his work, otherwise the plants will suffer. The nearer the ideal soil conditions for each crop are attained, the less, other things being equal, will be the difficulties in the way of successful crop production.

Owing to the fact that we have no definite rules to follow in this matter, it would be well for everyone growing plants on a large scale to have constantly under way experiments to obtain light on the subject. Such experiments may be made on a small scale, will cost but little, and would doubtless be the means of bringing many interesting facts to light. Some soils that do not give the best results for certain crops might be greatly improved by the addition of clay, sand, or silt; in fact, there is any number of combinations in this direction that might be used to advantage.

WATER, HEAT, AND LIGHT.

The importance of water in the growth of plants under glass has already been briefly referred to in discussing the question of soils. It is hardly necessary to say that the proper use of this element is the keynote to success; in fact, it has been truly said that he who does not know how to water plants does not know how to grow them. No absolute rules can be laid down for the use of this all-important material, as knowledge on such matters can be gained only by experience and the closest observation.

As pointed out in discussing the soil, the amount of air it contains has an important bearing on the health and vigor of the plant. Water plays a very important part in this matter, for the more water there is in the soil the less space will there be for air. By the improper use of water, therefore, air is excluded from the soil and vari-

ous complications are brought about, all of which directly affect the health, vigor, and productiveness of the plants. One of the results of the improper use of water in a soil naturally heavy is the formation in the roots of plants of alcohol and other substances destructive to growth. The roots in such cases are slowly suffocated, and the gradual decline and death of the plant is the result.

The improper use of water may affect plants in another way. The soil may be made a little too wet, and the air in the houses may also be oversupplied with moisture. These conditions are most likely to occur in winter. As a result of this certain changes are brought about in the tissues which make them more subject to the attacks of parasites, especially fungi, and also render them liable to other injuries, such as burning, scald, spot, etc.

Although not generally recognized, the method of applying water may have a decided effect on the growth of the plant by changing the structure of the soil, i. e., the arrangement of the soil grains and their relation to each other. It will be seen that the continuous and more or less forcible application of water to the surface of a soil on a greenhouse bench will have effects similar to dashing rains out of doors, that is, it will compact and puddle the soil and wash the smaller materials to the bottom, thereby changing its capacity for air, heat, etc., and thus directly influencing the development of the plant.

The soil should be kept open at all times to the free access of air. This may be done by keeping the surface stirred, by careful attention to watering, and, as is frequently done, by using a light mulch of manure or some suitable material to break the force of the falling water.

The importance and necessity of a proper amount of heat and light in greenhouses are well understood. It is very often the case, however, that the smaller details in matters of this kind are overlooked or neglected, and the plants in consequence suffer. Different plants, as is well known, require different temperatures for their best development. These differences, as is also well known, vary not only with different varieties and forms of plants, but also with the different stages in the growth of the same. The plant in its relation to heat has been likened to a steam engine.[1] When the tension of the steam is slight, the machine is barely able to overcome the friction of its own parts, and under such circumstances can do little or no work. As the tension of the steam is increased, the efficiency of the engine becomes greater and greater, until finally it reaches a point where the very best work is done. If the tension of the steam is increased beyond this point, the parts of the machine become strained, and the whole will eventually break down unless relieved of the pressure put upon it. In the case of a plant there is a point in the temperature barely sufficient to awaken the vital energies of the organism. With increasing heat

[1] Sachs, Physiology of Plants.

the vital forces of the plant increase, until a point is reached when the best growth is made; beyond this point the plant suffers, and is eventually killed if the temperature continues to increase.

In considering the question of heat, the importance of soil temperature and its relation to the temperature of the air must not be overlooked. Unless the proper conditions are maintained in this respect, an ideal development can not be reached, and the plants, in addition to developing characters that make them unprofitable, are frequently made more subject to disease. A striking example of the latter is found in the case of lettuce when forced under glass. At certain stages of growth the plant in question is much subject to burn or scald, and for this reason it is often rendered wholly unfit for market. The burn is primarily brought about by the rapid evaporation of moisture from the leaves at a time when the roots are not able to supply the demand for water. The temperature of the soil has a marked effect on root action, and in this way the supply of water made available to the leaves is influenced. If the soil is cold, or, in other words, if the relation of its temperature to that of the air is improper, the roots can not furnish the water as fast as it is needed, and in consequence the tender tissues of the plant above ground simply collapse.

The value of light in the growth of plants is not always fully appreciated. It is a common occurrence to see plants which require strong light for their development struggling for existence in dark houses half buried in the ground. Within recent years, however, there has been a marked improvement in the manner of constructing greenhouses, and there is no doubt that the improvement in many of the crops now grown can be attributed to the recognition of the fact that properly regulated light is one of the fundamental factors in the growth of crops under glass.

It must be borne in mind that we can have rapid growth even in feeble light, provided the necessary heat and other necessary conditions are present. Such growth, however, is not accompanied by proper nutrition and, if continued, the plant finally grows itself to death. A familiar example of this is found in the case of a potato, which may sprout and grow in a warm, dark cellar, and yet so long as light is excluded there is little or no actual gain in weight. Light, therefore, is the energy which builds up the tissues, and unless it is properly regulated the plant will eventually suffer. Although light is exceedingly important in the development of plants, it may act injuriously if too intense. This is frequently seen in midsummer in the case of plants growing out of doors, where the foliage, exposed to the full rays of the sun, fade out and turn yellow, the whole plant having a sick, leathery look, the leaves being smaller and the branches more or less stunted. The same thing may often be seen in greenhouses, especially as spring advances and the light becomes strong. The necessity for properly regulating light by shading is here shown,

but it is too often the case that proper judgment is not exercised in the matter. Remembering the rôle of light in the growth of plants, it will be seen that any attempt at lessening its intensity should be made gradually, so as to give the plant an opportunity to accommodate itself to the changed conditions.

SELECTION AS A MEANS OF INCREASING THE VIGOR OF PLANTS.

Within every plant there is an inherited disposition to develop along certain lines, and at the same time there are numerous influences operating from without which tend to advance, retard, or wholly restrict such development. It follows, therefore, that there is a constant struggle between the vital forces inherited by the plant and the conditions of its environment. In view of this fact, it will be seen how necessary and important it is to start with a plant having sufficient inherent force to enable it to attain the highest possible development. This, after all, is the basis of success, for if a plant possesses only sufficient inherent qualities to develop to a certain point, no amount of care, energy, or labor can, as a rule, make it go beyond that point. To understand this matter fully, we must look upon the plant not as an individual, but as a community of individuals, each of which is in a certain sense struggling for existence. This is the case with a rose, a carnation, a violet, or any similar plant which the gardener grows. Each joint of the stem with the leaf and bud attached will, as we know, grow into a new plant when placed under the proper conditions. This, therefore, is an individual, so far as we are at present concerned, and as such possesses certain characters which may or may not differ from all other similar parts of the parent plant. These characters may be in the nature of a more vigorous constitution, a tendency to throw larger flowers and many of them or the reverse, a predisposition to disease, an imperfect leaf development, and so on through a number of possibilities.

It is hardly necessary to enter upon a discussion as to how these differences are brought about. Suffice it to say that they are not generally recognized; in fact, it is only when the changes are so great as to bring about an extreme form, or "sport," that attention is called to them. It needs little argument, however, to prove that they exist, for everyone who propagates plants by cuttings knows that hardly any two of them possess exactly the same characters. Starting with two rooted cuttings from the same plant, and growing them under as nearly the same conditions as possible, one may give a plant that will bloom freely, forming flowers of large size, and its leaf development may also be perfect, while the other may be a vegetable runt, lacking in vigor of leaf and utterly unable to give anything but small and imperfect flowers. The importance, therefore, of proper selection in propagating all plants by cuttings can not be too strongly emphasized.

This is especially true in such plants as roses, carnations, violets, etc., grown for their flowers.

In considering this matter, however, our first proposition must not be overlooked, viz, that growth is influenced by two forces, the inherited disposition within and the conditions of the environment. The first effort, then, of the gardener should be to start with cuttings which he knows by observation will fulfill as nearly as possible the ideal conditions as regards vigor, the ability to flower, or whatever the requirements may be. But this is not all, for the method of treating the cutting after it is removed from its vigorous parent may largely influence its future growth and value. The cutting, so far as appearances go, when taken may be vigorous, yet its tissues may be immature or too old, and in either case a weak plant, if one is obtained, will, in all probability, be the result. We may illustrate this matter by the accompanying cuts (half natural size), made from photographs of violet cuttings of various kinds.

FIG. 53.—Violet cuttings from old wood.

Fig. 53 shows two cuttings, or rather two rooted offshoots, one-half natural size, of a plant which was in good health and was making growth rapidly. The probabilities are that these cuttings would never make good plants. The stems, as can be seen from the leaf scars, are hard, their tissues being fixed and almost incapable of further growth. The roots also are tough and hard, and therefore are of very little use to the plant. Such plants when set out may struggle along and live for a year, but will always be stunted and will seldom, if ever, pay for the space they occupy.

In fig. 54 is shown another type of cutting, in this case immature or soft wood being used. Such cuttings are very likely to damp off while being rooted, and are also very subject to spot and other diseases. If successfully rooted they are apt to make plants that are weak, prone to disease, and lacking in ability to make good flowers and many of them.

Fig. 55 shows another type of cutting, which may have vigor enough at the start, but which, owing to the way it is made, will never form a good plant. There is not sufficient stem to anchor the plant in the

ground and in consequence it will roll around, and every time a flower or leaf is pulled some of the roots will be broken.

FIG. 54.—Violet cuttings from mature wood.

Fig. 56 shows an ideal type of cutting, one that under proper conditions of soil, moisture, heat, etc., will make a vigorous, free-growing plant. In this case the tissues were neither too young nor too old, and the mass of young, active, working roots is ready to begin work as soon as the plant is placed in the soil.

FIG. 55.—Violet cutting with insufficient stem.

In addition to the foregoing considerations, the important factors of water, heat, air, and light must not be overlooked in dealing with cuttings of all soft-wooded plants. The cutting, as soon as it is severed from the parent plant, becomes an independent constructive apparatus, and as such it must be surrounded with the proper conditions for work. Light is especially important, for here, as in the growth of the plant proper, it furnishes the energy for the manufacture of food, from which, in this case, the new roots are developed. Briefly, every effort should be made to surround the young plant with the very best conditions for its development, as a check at this time, while apparently a trivial matter, may in the end cut a serious figure in the returns.

FIG. 56.—Ideal type of violet cuttings from mature wood.

We have now briefly reviewed some of the more important factors which may influence the vigor, productiveness, and profitableness of plants grown under glass. The man who would succeed in this work must by patience, vigilance, and constant care learn to see and feel what his plants require and spare no effort to meet their every need.

PRINCIPLES OF PRUNING AND CARE OF WOUNDS IN WOODY PLANTS.

By ALBERT F. WOODS,

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The purpose for which any particular tree is grown must always be kept clearly in mind. If grown for wood, it will require one kind of treatment; if cultivated for fruit, it will require another; if grown for shade and artistic purposes, still another treatment may be needed.

The tree, like any other plant, is greatly influenced by conditions of environment, such as light or heavy soil, the amount of water and air which the soil contains, the character of the subsoil, and the general climatic conditions of the region. It is necessary to know how the plant responds to these various factors, and how different combinations of conditions produce different effects. Even after the grower has selected a tree naturally adapted to certain conditions, it will still be necessary to more or less control growth, according to the needs in view.

Growth may be controlled in a number of ways, one of the most important of which is pruning or cutting off certain parts of the plant. No popular notion is more erroneous than that any person can properly prune a tree, transplant it, or successfully care for it in other ways. The knowledge of the experienced horticulturist is often taxed to the utmost when dealing with these questions. It is folly, therefore, to leave the care of trees to inexperienced men. The experienced grower does not blindly follow a set of rules in this matter. He has learned by observation to adapt his treatment to the varying needs of his plants, but his actions are governed by fundamental principles, and a knowledge of these would be a great help in enabling him to adapt the treatment to varying conditions.

The purpose of this paper is to point out some of the principles in plant physiology upon which the practice of pruning depends, for the benefit of those who have not already learned by experience when to prune, how to prune, and how to care for the wounds produced.

GENERAL STRUCTURE OF WOODY PLANTS.

In practically all woody plants, except the palms and their relatives, four general groups of tissues may be distinguished in the trunk and branches, namely, bark, cambium, wood, and pith. These various

parts are shown in fig. 57, where it is seen that the bark, *b*, forms the outer covering; the cambium, *c*, is a thin, slimy layer between the bark and wood; the wood, *w*, forms the greater portion of the stem; and the pith, *p*, makes up the central portion.

The cambium is the most important of these tissues, from the standpoint of this paper. It is a thin layer, made of brick-shaped cells. These have very thin walls, which are easily torn, especially in the growing season. It is the cambium which gives way when the bark is stripped from the wood. During the growing season the cambium cells divide, giving rise on the inside to a layer of wood cells, consisting mainly of fibers and vessels or their equivalent, while toward the outer side at the same time a layer of bark cells is formed. A thin layer of cambium cells is left between the new bark and the new wood to repeat the process of forming a new layer during the next period of growth. This ordinarily occurs the next year, but may take place the same season, according to circumstances. These layers are readily distinguished in most trees and shrubs, and are called annual rings (fig. 57). The bark layers are also in rings, but are usually less evident than the layers of wood.

FIG. 57.—Cross section of trunk of sassafras tree, photographed natural size. *b*, bark; *c*, cambium; *w*, wood; *p*, pith. The annual layers or rings show both in wood and bark.

In all trees, except some with smooth bark, the outer bark layers soon cease growing, and as successive ones are formed underneath, the outer layers are split and torn, and either peel off, as in the cherry, plum, sycamore, Chinese quince, birch, sassafras, etc., or remain and form roughened projections, as in all rough-barked trees, as shown in fig. 64. Sometimes these outer layers split with difficulty, thus subjecting the growing cambium to great pressure, often so great that it almost stops growth. Trees in this condition are said to be "hidebound." The remedy is to scrape off the old bark or cut longitudinal

slits in it, thus giving the underlying layers an opportunity to form. Only the outer bark should be scraped off, but the slits may be cut down to living tissue. The same end may be reached by fertilizing and cultivating the trees, thus stimulating growth. The cambium thus stimulated is able to break the outer bark. The cambium is the only tissue which retains the power of active growth. The wood and bark layers formed from it remain alive for several years after they have completed their growth, but after this they die and become useless except as protective and supporting tissues. There is an exception to this rule in some smooth-barked trees, where the bark remains alive and retains the power of growth for many years. Except in the youngest twigs, therefore, the heartwood and all except the youngest sapwood is practically dead. The same is true of the outer bark layers where they remain attached to the stem during successive seasons of growth. Some of the inner bark cells outside the cambium retain the power of growth and produce cork cells.

THE ROOT.

For the purpose of this paper, the root may be considered as simply a branched extension of the stem under ground. The cambium of the stem, being continuous with that of the root, forms at each period of growth a layer of wood cells on the inside and bark cells on the outside. An old root, therefore, usually shows concentric layers, similar to those of the stem, the inner and older wood layers being dead, while those bordering on the cambium and a few deeper layers are living, as in the stem. The same is true of the bark. All except the younger layers have become corky and have lost the power of growth and of absorbing water. It is only the younger roots, with living bark, therefore, that are able to supply the plant with water and what is dissolved in it. If these feeding roots are destroyed or are very greatly injured in transplanting or in any other way, new ones will have to be produced before the plant can make any healthy growth. These new roots start from the cambium layer underneath the bark and most readily from the younger roots. In removing large trees or shrubs the feeding roots are often destroyed and the older roots may be very slow about sending out new ones, especially when the old roots have a strongly developed bark, when the soil temperature is too low, and when there is not enough moisture in the soil. If leaves are formed before the new roots are developed, the moisture of the stem is soon exhausted and the plant dies.

The most important point to keep in mind, therefore, in moving any plant is that it must have enough feeding roots to support top growth when it starts. To insure this, the top is usually cut back to correspond with the quantity of roots left. Some planters seem to think that this is all that is required. They cut the top down to a pole in late winter or early spring, chop the roots off a few feet from

the trunk, and move the tree to its new locality. If it happens to be a tree like a pear or a peach, which produces new roots readily and has enough nourishment stored up in the trunk to furnish food for it and the new branches when they start, it may succeed in getting established before the hot summer weather comes on. However, if it is one of the harder woods (nut or ornamental trees) the chances are that under such treatment it will either die immediately or succumb after a struggle of a few years. In many such trees the feeding roots are far removed from the main stem, and so are almost entirely lost in taking out the tree, no matter at what time of the year it is removed. It is much better, therefore, to cut some of the main leaders back early in the fall, the year before removal, making the cut clean and smooth with a saw, if the roots are large. The new roots will often start during the fall, and if not in too cold a region will make some growth during the winter and a great deal during the following spring and summer. By the next fall a good supply of feeders will have started, and the tree may be quite safely moved to its new location without such severe cutting back. In the northern United States quite heavy mulching of transplanted trees is beneficial as a protection to the ground underneath from severe freezing and thawing.

While what has been said applies particularly to transplanting rather large trees, it also holds good in putting out those kinds of nursery stock in which the root development is inclined to be slow. In moving evergreens greater care is necessary than in moving deciduous trees, as the constant presence of the leaves on the former always keeps up a continuous demand for water.

In transplanting a tree or any other plant every root that is cut or broken should be pruned smooth, with as little injury to the remaining tissue as possible. The cambium layer thus exposed, and often the young wood and bark cells, grow over the wounded places, forming a cushion, or callus. The cambium layer between the modified bark and wood of the callus gives rise to new roots often more readily than the cambium of the older parts of the root, possibly on account of the greater resistance of the bark on the older portions. Where it is desired to hasten the development of secondary roots, it might pay to slit or partially remove the old bark at certain points, as in layering. It is always necessary to keep the wounded ends from drying out, because drying kills the cambium and so prevents the healing of the wound. To accomplish this it is only necessary to keep the roots in moist soil or in some place not exposed to dry air.

ROOT PRUNING.

From what has been said it is evident that root pruning, when properly done, has its uses in connection with transplanting, but even here it may be looked upon as a necessary evil and is to be avoided to the

greatest possible extent. The removal of dead or diseased roots back to living tissue is, of course, always proper. Such roots are never of any value to the plant, and are always a source of danger. If they are cut back to living cambium and sound wood, the wound will gradually heal by the production of a callus. A surface bruise, or wound, if it goes through to the cambium, should be cut back to living cambium on all sides with a sharp knife and the wound covered with moist soil. If it does not go through the bark, cork cells will be formed and it will require no attention. Root pruning is sometimes resorted to as a check to rapid top growth, especially in young apple trees in the nursery when attacked by twig blight. If carefully done, it may accomplish the end sought without great injury to the young trees. The stimulus which it gives to the production of new roots close to the trunk is valuable, as such roots are a decided advantage to trees which are to be moved.

Root pruning to produce fruitfulness depends on the physiological principle which holds all through the vegetable kingdom, that a check to vegetative development induces the production of fruit. This check may be brought about in two very different ways: One is by giving a check to the whole plant, as is the case in root pruning or severe top pruning, which removes many leaves during the growing season and thus cuts down the food supply to the plant as a whole; the other way is to check the active growth in length of undesirable parts, thus leaving for other parts the nourishment which they would have used. The total food supply for the plant is not increased or diminished by this process, but the food is more generally distributed. The first method, viz, checking the plant as a whole by root pruning or severe top pruning during active growth, must be practiced with great caution, as such a check is liable to result in permanent injury to the plants. Pinching back to secure distribution of growth, however, is a different matter, few leaves being removed in this process. In this case nearly as much sugar is made by the plant as before, and it is left for the use of lateral buds and the annual layer of wood and bark in process of formation. Many of these lateral buds starting at once will usually not make a strong vegetative growth, so that the fruit buds may start with a good supply of available food to draw on.

TOP PRUNING.

The advisability of controlling the growth of a tree in any way depends upon circumstances. In nature the growth of all plants is modified and controlled to a large extent by conditions of environment. Thus a certain tree in the open field may have a short, thick trunk and a spreading top, while the same kind of a tree in the forest has a tall, slender trunk and narrow top. Vegetation on the high mountain sides and dry plains is low and spreading, while in the moist valleys and canyons the same kind of plants are large and well

developed. In growing trees and shrubs for shade or artistic purposes it is usually most satisfactory to give them the opportunity of doing their best in their own way.

In most cases, however, it is not what a plant naturally does, but what it can be made to do, that makes it valuable. It is this making plants do what we want them to do that constitutes cultivation. Pruning is one of the most common and valuable methods of directing and controlling the energies of plants. Whether or not it may be necessary to control them in any given case depends upon whether or not, under given circumstances, it will increase the efficiency of the plant for the purpose for which it is grown. In all pruning the fact should be kept in mind that the leaves make nearly all the food used by the living cells of a tree. If the leaves are removed, the cells must undergo a corresponding process of starvation until new leaves are formed.

FIG. 58.—Trunk of maple showing hole left by decaying limb.

NATURAL PRUNING.

Natural pruning is always taking place, especially in woody plants. The shedding of leaves and twigs is a familiar example. The death and gradual decay of branches, due to shading, starvation, crowding, freezing, or various mechanical injuries, may also be placed under this head. There can be no question but that the artificial removal of all branches which are dead or dying is beneficial to the plant. In the natural shedding of leaves or twigs a layer of cork-like cells is formed between the part to be cut off and the parent plant so that when the leaves fall the process of healing is very soon completed. In the death or decay of branches, however, no such natural cutting off occurs. The old stub remains for a long time, gradually decaying down into the larger limb or trunk, so that when it does fall it leaves a hole, in which water may gather and rot-producing fungi and bacteria develop, and thus spread decay in the sound wood. Fig. 58 shows a hole left by a limb which has decayed in this way.

If all such limbs were cut off close down to the shoulder, or enlargement, at their base, the living cambium and bark would heal the wound in the course of a few years, and the internal rotting would usually be avoided, especially if the larger wounds were painted over, as soon as dry enough, with coal tar. This kind of pruning, at least, is applicable and beneficial to all trees, no matter for what purpose they are being cultivated, and even if they are not being cultivated at all. It may be all that is required in park, shade, and ornamental trees, especially if the natural habit of the tree in question is suited, as it should be, to the locality in which it is grown. This is not the case very often, however, particularly in parks and along streets, where modified conditions may demand a different shaping of the tree. Any modifications necessary should be made here, as in all other cases, while the trees are young. If this precaution has been neglected, the change may have to be made in older trees. In this case it must be done gradually through a series of years, as severe cutting back at one time is dangerous, and unless carefully followed up by judicious after-pruning scarcely ever results in anything but a brush heap for a top, and besides it weakens and stunts the future growth of the tree. Fig. 59 shows a soft maple cut off in this way and not properly cared for.

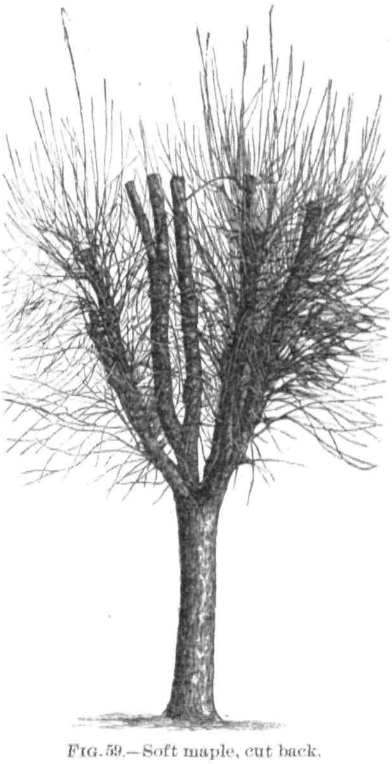

FIG. 59.—Soft maple, cut back.

PRUNING FRUIT TREES.

In fruit trees especially, the object and value of pruning becomes most apparent. A fruit tree is in a certain sense a machine for manufacturing fruit. The sole objects of its propagation and cultivation are (1) to obtain a plant that will do the best and most work for a given amount of money and labor expended upon it, and (2) to keep it in a condition so that it will continue to do this kind of work. Pruning is one of the most important means by which this is accomplished. Pruning to shape the tree and keep it in shape is important so far as it relates to ease in cultivation, gathering the fruit, and spraying; also in relation to winds, supporting the weight of the fruit, protection of trunk and limbs from sun scald, etc. This includes

also pruning to distribute growth from one part to another, cutting out undesirable branches to give room and nourishment to those which are desired, and checking terminal branches to induce the development of laterals. All this is to keep the tree vigorous and well supplied with thrifty, fruit-producing branches, and not allow it to spend more of its energy than necessary in making wood, for which the tree is not grown. The balance between vegetative and reproductive growth, or between wood and fruit, must be maintained. It is not, however, the object of this paper to give specific rules for securing these results, but rather to discuss the general principles on which such rules or practice should be based.

The effect on the plant of pruning depends very largely upon the time at which it is done. If the new wood growth is checked by removal or in any other way during active development, the growth of flowers and fruit will be stimulated. On the other hand, if the growth of flowers and fruit is checked, vegetative growth will be stimulated. The most active and vigorous parts of a plant are the ones which will get the most nourishment. While these parts are making active growth, other parts will grow very slowly. The relation between vegetative and reproductive growth, however, is not wholly a matter of nourishment.

There are two natural, inherent methods of reproduction in plants. The first is the production by the parent plant of vegetative buds, shoots, etc., which may be separated either naturally or artificially and new plants produced from them. It is this method of reproduction that is stimulated when it is desired to propagate a plant rapidly by cuttings. Vegetative growth is therefore nothing more or less than vegetative reproduction, whether the buds and nodes produced are ever separated from the parent plant or not. The second method of reproduction is by the formation of seeds or fruit. The comparative strength of these tendencies depends on the age and environment of the plant and the purpose for which it is cultivated. In the case of annuals and biennials the life of the plant consists of two stages. During the first, the vegetative reproduction or growth predominates; during the second, reproduction by the formation of fruit predominates, and after fruiting the plant dies. In perennials, such as our fruit trees, the same alternation between vegetative and fruit reproduction may be traced, but it is more obscure, and the phases often overlap each other, because the ripening of the fruit is not followed by the death of the tree, but by a period of renewed vegetative growth. In fact, the two tendencies are present and active throughout the life of the plant, the one being predominant and then the other, in more or less regularly alternating periods.

This periodicity between vegetative and fruit growth is what must be controlled by the successful cultivator, and pruning is often an important means to that end. If one kind of reproduction is getting

too much the advantage of the other, it is only necessary to check the predominant one. Cutting off developing vegetative buds and branches, therefore, *during the period of active vegetative reproduction* checks this phase, and the pushing of the fruit buds follows. Pruning to produce fruitfulness consists, therefore, in pinching or cutting off the terminals of rapidly developing branches. If the tree is a very vigorous one, new vegetative shoots may start from the lateral buds, and these will have to be pinched back in the same way. Whether or not this process will be necessary in order to regulate bearing will depend largely upon circumstances, such as the kind of tree, soil, climate, etc. The citrus fruits, for example, are not pinched back or headed in, because the fruit is borne near the ends of the branches and the proper balance between the fruit and wood growth is maintained naturally. The only pruning necessary in California and Florida for these fruits is to keep the inside of the top clean from dead and useless branches. In California most fruit trees are inclined to bear early and overbear, so there pruning during the growing season is seldom practiced, except where it is necessary to check rapid growth. The same is often true with earlier varieties of fruits in the eastern and southern United States.

Checking vegetative reproduction by root pruning has been sufficiently discussed in the first part of this paper. Another method often resorted to is to cut down the water supply by stopping cultivation and seeding to grass or clover or some deep-rooted crop which will dry out the soil, thus decreasing the supply of water to the trees. Grafting into a restraining stock, so much practiced in pear growing, where the trees so grafted are known as "dwarfs," is a valuable method of retarding vegetative development sufficiently to promote fruit development.

OVERBEARING.

With some fruit trees grown on a commercial scale the greatest difficulty is overbearing. The direct remedy for this rather desirable defect is to thin the fruit, or to remove it altogether in the case of very young trees, and to stimulate vegetative growth by pruning when the tree is dormant, as described later. The principles underlying this practice are the same as have been discussed in pruning to produce fruitfulness, but the check in this case is given to the fruit instead of the vegetative growth. It is a common thing, especially in orchards which have been allowed to take care of themselves, to find trees bearing a large crop of fruit only every other year. The large crop exhausts nearly all the food made during the season, so that the vegetative growth following is slow and prolonged. The remedy of thinning in connection with pruning usually restores the balance between wood and fruit growth, and fruit of much better quality is produced each year, besides restoring the development of vigorous wood which may continue to bear satisfactorily.

PRUNING FOR VEGETATIVE GROWTH.

All the more general pruning for shaping the tree and keeping it vigorous and healthy is done during the dormant period in fall, winter, or very early spring. This, of course, does not check either phase of reproduction unless the fruit-bearing wood is all removed, as it sometimes is by inexperienced workmen. The purpose is to cut out all undesirable twigs and branches so as to leave all the stored-up food for the use of those left. Trees which have been stunted by overbearing, drought, or by any disease not permanent may be stimulated to produce vigorous new wood in this way. Careful and systematic pruning during the dormant season is the means most commonly used to keep the tree well supplied with vigorous bearing wood and to maintain the proper proportion between vegetative development and fruit production. It is essentially the renewal system so well known to grape growers.

HEALING OF WOUNDS ON STEM AND BRANCHES.

Attention has already been called to the point that all limbs and branches removed should be cut close down to the shoulder, so as not to leave a "stump" which will not heal over. Fig. 60 shows an oak tree from which many of the upper limbs have been cut, leaving stumps. These ends are not healing, but are gradually dying down into the trunk. Some of the lower limbs have been cut properly and are already healed or in process of healing.

The direction of the cut will depend largely on the position of the branch, but it should always be sloping as much as possible, so that the water will drain off readily. It is very important that the healing process start soon after the wound is made, otherwise the cambium will dry out and die quite a distance back from the exposed edge of the wound, and after this healing will be greatly retarded. One of the dangers of winter pruning comes from the freezing and drying out of the cambium on the edges of the wound. This is least liable to occur in fall and very early spring pruning. At these times the healing growth of the cambium starts very soon after the wound is made. In cutting off very large limbs it is always difficult to keep the tissues on the lower part of the wound from being bruised and torn. Of course, a tree should never be allowed to get into a condition where it becomes necessary to remove a large limb. If the necessity should occur, however, two cuts should always be made, one several inches or a foot from the shoulder of the limb, to remove the weight and keep it from crushing the tissues which are to heal the wound. The piece left should then be cut close down to the shoulder, so that the healing rim may easily grow over the exposed surface. Large wounds should have the exposed surface protected by grafting wax, grafting clay, or burned coal tar. The first two mixtures are best as a protection against drying out; the latter is the best protection against the starting of rot in the wood.

Surface wounds in the trunk or large limbs, if they do not extend through the cambium, will heal readily over the whole surface if they are kept from drying out. Grafting clay or grafting wax may be used as a dressing for this purpose, though the thick coal tar is just as good. If the wound extends through the cambium, it will only heal from the edges. Dead or diseased tissue must be removed and the wound treated as if it were a large limb cut off, protecting the exposed surface with grafting clay or coal tar. If such wounds are not cleared of dead tissues, water collects under the bark, borers make it their starting point, fungi and bacteria develop, and the surrounding tissue rots as a result of their work. Wounds which have reached this condition can not be too quickly cleaned and put in a condition to heal. All holes should be plugged with wood. Fig. 61 shows the wood rotting where a large limb has been cut from a tulip tree and the exposed surface left untreated. The rotten wood should be cleaned out, the hole plugged with dry wood, and the surface covered with coal tar. If the coal tar had been put on soon after the limb was cut, no rotting would have occurred. Enough has been said to show clearly that a tree is a living, responsive organism, and that it requires more careful and considerate treatment than it usually receives, especially in parks and along streets.

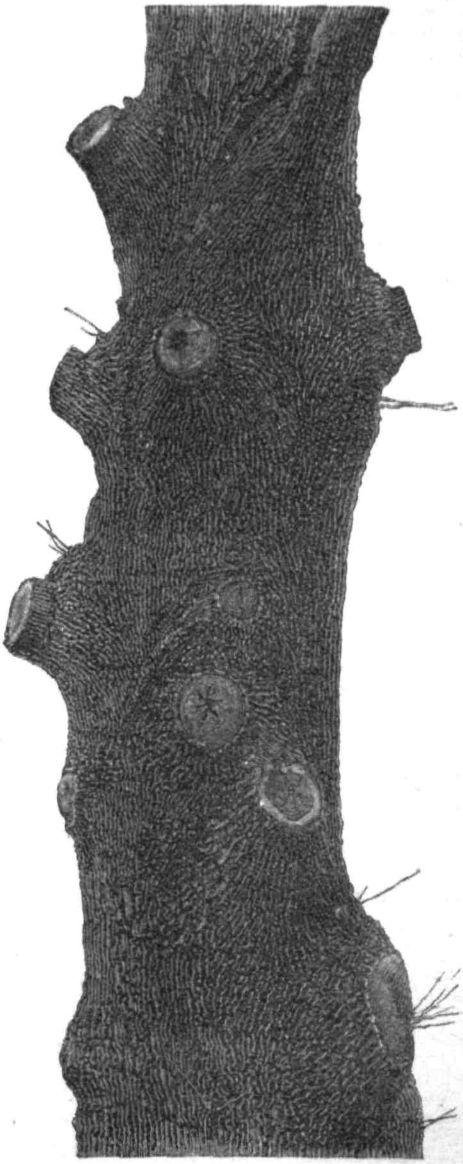

FIG. 60.—Oak tree from which some of the lower limbs have been properly cut and most of the upper ones improperly cut.

RECIPES FOR GRAFTING WAX, ETC., USED IN PRUNING.

Grafting wax.—One of the best grafting waxes is made by melting together four parts by weight of resin, one part beeswax, one part tallow. When thoroughly melted, pour into cold water; when cool enough, take out and work by molding and pulling until it becomes quite stiff. It is necessary to have the hands well greased with tallow while handling this wax.

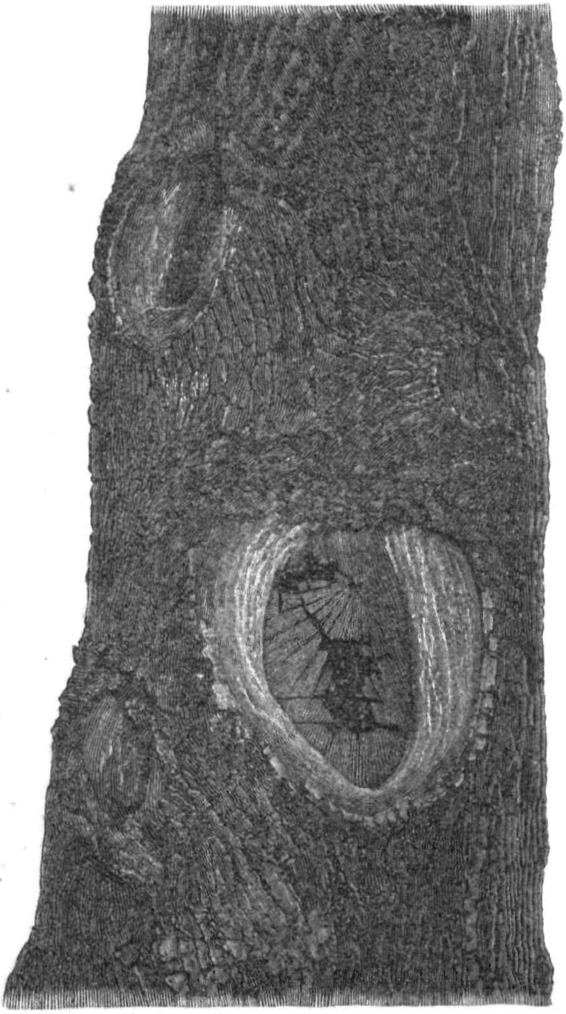

FIG. 61.—Showing where large limb has been cut from tulip tree.

Grafting clay.—One-third fresh cow dung, two-thirds clay, with a little plaster hair. Thoroughly mix and allow to dry until about the consistency of fresh putty.

Coal tar.—Coal tar and pitch mixtures should be applied to wounds after they have been cleaned, pared, and allowed to dry enough so that the material will stick. Thick tar is one of the most easily applied and best dressings there is. In Florida the coal tar is thickened by burning it in an iron kettle until it reaches the desired consistency. It is painted on the wounds while still slightly warm. Thus prepared, it dries quickly, forming a hard, glazed surface, which does not crack or peel off, as is the case with pitch, shellac varnish, paint, etc.

Shellac varnish.—Shellac in just enough strong alcohol to dissolve it. This is a very good dressing for wounds, but it is more liable to crack and scale off than coal tar, and is more expensive.

THE PINEAPPLE INDUSTRY IN THE UNITED STATES.

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The pineapple is indigenous to South America. For many years it has been generally recognized as one of the finest of the tropical fruits, and may be safely said to rank first among those supplied to the markets of the United States. It is true that certain other tropical fruits, such as the mangosteen and durian, may probably be considered superior to the pineapple, but as yet these have not been sent to American markets.

EXTENT OF PRODUCTION.

The pineapples consumed in the United States have been and are still largely imported, the West Indies and Bahama Islands being our main sources of supply. Three-fourths of the pineapple crop of these islands comes to our markets. It is estimated that Cuba alone sends annually about 1,200,000 fruits. The Bahama Islands export each year about 7,800,000 fruits, most of which are sent to the United States. San Francisco and the markets of the West Coast are largely supplied from the Sandwich Islands.

For a number of years pineapples have been grown to some extent in Florida, but it is only within recent years that the quantity produced has been worthy of consideration. During the last decade railroad extension and the improvement in shipping facilities generally have led to a rapid development of the pineapple industry in the southern portion of the peninsula. In the year 1894, 56,209 whole or barrel crates, or about 3,000,000 fruits, were shipped from the State. In 1875 the number of imported fruits received at the port of New York was 5,785,755, and in 1882 the number received at the same port was only 2,533,320. These figures are a good illustration of the rapid decrease in the number of fruits imported, and the correspondingly rapid increase in home production.

The pineapple is a very tender fruit, and therefore easily injured. As the regions where it is grown are mostly isolated from general shipping lines, it is often difficult and sometimes impossible to secure proper means of transportation, and on this account Europe and North America have to be supplied by the pineapple regions lying near them.

With proper refrigeration and fast steamers, however, the pineapple could be shipped safely from any part of South America to the United States or Europe. In Florida the growers have the advantage of being near the principal American markets and of having direct railroad communication with many of them, and notwithstanding the fact that they have to compete with foreign pineapples, which are now entered free of duty, the industry is considered very profitable in Florida and is rapidly growing.

DEVELOPMENT OF THE PINEAPPLE INDUSTRY IN FLORIDA.

Pineapple culture, according to the statement of Mr. Reasoner,[1] was introduced into Florida about the year 1860.

The pineapple, which is strictly a tropical fruit, is very easily injured by low temperatures. Usually it is impossible to grow it in

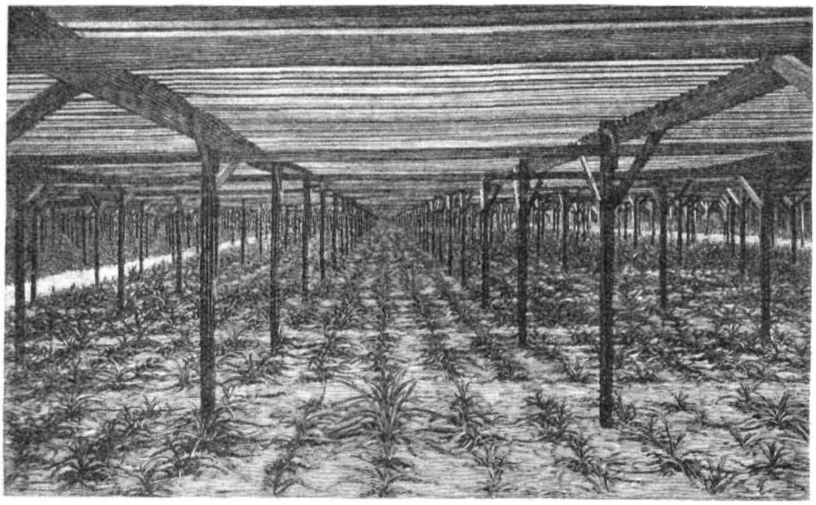


FIG. 62.—Field of pineapples growing under shed, showing newly set plants and illustrating the methods of setting.

open field culture outside of the tropics, unless in regions protected by water and tempered by warm ocean currents, as in the case of the Bahama and Azores islands. The pineapple can not stand even a light frost. Selmer, in his Tropical Agriculture, cites Florida as an illustration of a region where light frosts occur and where pineapple culture consequently can not be made successful. However, in view of the thirty-five years' experience now had in pineapple growing in Florida, the gradual but very great extension of the industry, and its uniform success in the southern portion of the State, it is safe to conclude that Selmer was somewhat hasty in his judgment. The pineapple can not be successfully grown in all parts of the State, and the portions where open culture can be safely adopted are indeed limited.

[1] Bull. No. 1, Division of Pomology, U. S. Department of Agriculture.

This method of growing the fruit, however, has generally proved successful south of about 27° 30′, below which frost seldom occurs, and has succeeded even 1 degree north of this in certain localities having water protection.

If severe freezes were of common occurrence in Florida, pineapple culture would have to be abandoned, but fortunately the freezes of 1886 and 1894–95 were the only severe ones which have taken place since the introduction of the industry. Certain localities have, however, been injured at other times. In general, the Gulf Coast is slightly colder and more subject to injury during the lesser cold spells than the Atlantic Coast, and for this reason the industry has spread almost entirely on the Atlantic Coast. There seems to be no reason, however, why the pineapple should not be extensively grown in the vicinity of Myers and farther south, for although light frosts

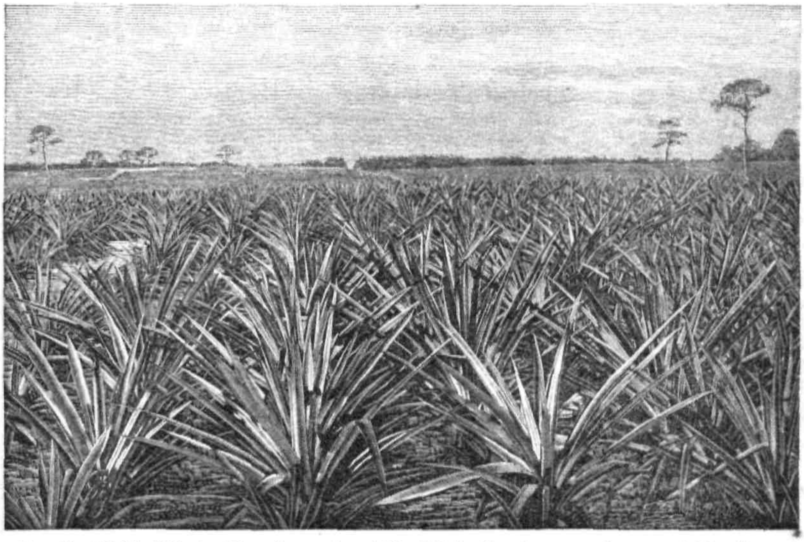


FIG. 63.—Field of Porto Rico pineapples at West Palm Beach, grown by open-field culture.

slightly injure the leaves, they do not necessarily impair the fruiting of the plants the next year.

In the early period of pineapple culture in Florida a considerable number of plants were grown in the central part of the State, in Lake, Orange, and Volusia counties. Although in this section it is frequently possible to secure three or four crops in succession in one season by covering the plants during the winter, as a whole the industry has proved unsatisfactory and has been largely abandoned. In the vicinity of Orlando, however, the pineapple is grown by a few with apparently excellent results. Here the plants are grown wholly under sheds, which are ample protection against light frosts. Somewhat farther south, at Avon Park and Pabor Lake, in the central part of the State, the industry has spread considerably, nearly 100 acres being

now planted. In this section open culture has proved fairly successful, but as yet is in an experimental stage.

At present most of the pineapple fields of Florida are located on the east coast south of Fort Pierce, in a strip of comparatively high land. This ridge is 1 to 2 miles wide and forms the west bank of the Indian River and Lake Worth. West of this ridge the land is low, marshy pine, which merges into the Everglades south of Jupiter Inlet. This entire strip of land, running along the east coast for over 150 miles, could be made a compact pineapple field if necessity should demand. Already fields of pineapples, containing from 50 to 100 acres in a block, may be seen here. Considerably north of this, on Merritts Island, which is protected by the broad waters of Indian River, there are some plantations, and these could be greatly extended. Plate IV shows a thrifty pineapple plantation at Jensen, Fla.

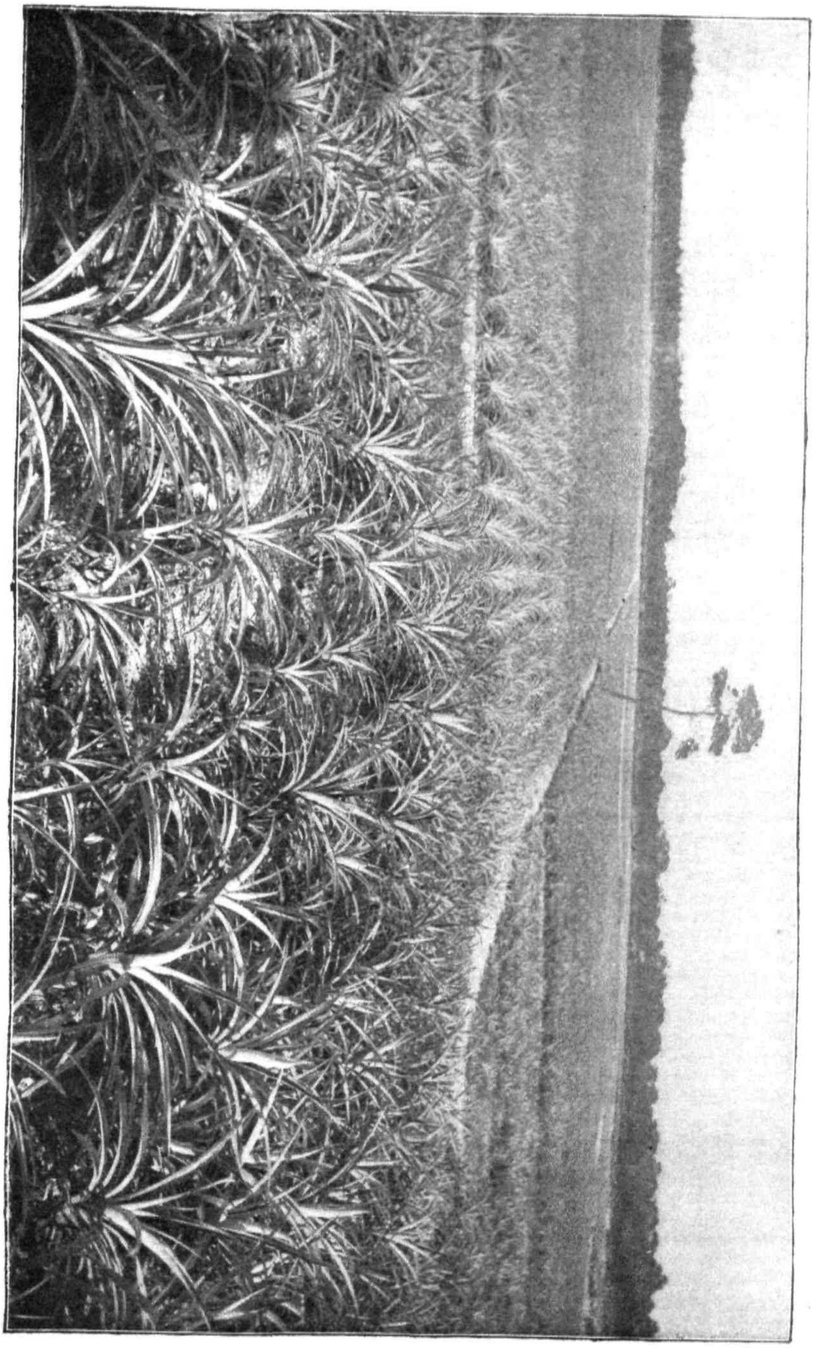
On the keys the soil on which the pineapple is grown consists of a very thin layer of leaf mold, which usually covers the ever-present coralline rock, although frequently the latter is not covered at all. The method followed here is to make a clearing, burn the brush and trees, and set out the plants wherever sufficient soil exists for their support. At about the time of the first planting, some tropical fruit, such as avocado pears, limes, sapodillas, etc., is set out among the pineapples. These reach bearing about the time the fruitfulness of the pineapple ceases, which is usually in about five or six years. After one planting of pineapples runs out, the soil is no longer fit to grow them, so that year after year the virgin forest is destroyed to give place to the pineapple. From the destructive nature of this method of culture the industry can have only a limited extension on the keys, for soon all the available forest land will have been planted.

At present there are about 2,389 acres[1] in the State planted to pineapples. This area, as may be seen from the above statements, may be greatly extended as the demand for the fruit increases. South Florida is the only region in the United States where pineapple culture has succeeded or is ever liable to succeed. The demand for the fruit is rapidly increasing and can not at present be supplied, and as foreign markets are open to Florida producers an outlet would be found in them should our own markets become overstocked. Our consul at Rheims, France, writes as follows: "Pineapples are almost unknown in France and the price is out of all proportion, but there is sale for them." There seems to be no probability, however, in the near future of an oversupply of this fruit.

CONDITIONS INFLUENCING GROWTH.

Heat.—The thermal conditions governing the successful growth of the pineapple have been discussed above. This fruit can not

[1] This estimate is based on lists of growers and the acreage cultivated by each, which were kindly furnished by growers in the various localities and may be considered as fairly accurate.



PINEAPPLE PLANTATION NEAR WEST PALM BEACH, FLORIDA.

withstand freezing temperatures, and the extension of the industry depends most largely on this condition. The mean annual temperature must also be high, as a region may seldom have frosts and yet be too cold for the successful growth of this fruit. The best pineapple regions in the world have a mean temperature of from 75° to 80°. The mean annual temperature of the Bahamas is about 76°; Key West, off the coast of Florida, has a mean annual temperature of about 76°; and Jupiter, in the midst of the pineapple region, about 73°. The annual mean in a large part of the pineapple section of Florida is thus comparatively low.

Soil.—Some difference of opinion exists among planters as to the quality of the soil best suited to pineapple culture. Selmer, in Tropical Agriculture, says: "A light, sandy, dry soil does not suit the pineapple, and even less a stony or marshy soil. The most suitable soil is a rich humus, with a clayey subsoil."

In Niihu and the Philippine Islands, where pineapples succeed well, the soil is disintegrated lava covered with a layer of humus. There is but little cohesion in such soils, particularly when, as in this case, they contain considerable lime. When clay is present, it is said to be important that it should not be so abundant as to hinder root penetration or hold the soil water, but a certain amount to increase the water-holding capacity of the soil is apparently very desirable.

The soils in Florida which have uniformly given the best results are composed mainly of fine sand and are extremely poor in the elements of plant food. Artificial fertilization is used in all places except on the keys, where the soil is a rich humus. It might be supposed that the soil in most places acts only as a basis for artificial fertilization, but such is not the case, as all soils will not answer. Coarse, sandy soils and shell lands are not suitable. Many plantations have been put out on shell land, but have uniformly failed, and therefore care must be used to select suitable soil. The land in Florida which planters generally consider best is that known as "hickory scrub." The surface soil is fine white sand, from 5 to 6 inches deep, and contains from 94 to 99 per cent of silica; the subsoil is a yellowish sand, of about the same chemical and mechanical constitution. The more abundant spruce pine (*Pinus clausa*) scrub land, where the soil can scarcely be distinguished from the hickory scrub, also gives good results. The pineapple lands of the Indian River and Lake Worth region are principally scrub lands of the above kind. The so-called high pine land, which is usually a gray surface soil, underlaid with a subsoil of yellow sand, is also considered good pineapple land. The flatwoods land, which is probably the most extensive of the various soil formations south of Lake Worth on the east coast and the Caloosahatchee River on the west coast, has been planted to pineapples to some extent and has given fair results. Hammock lands, which of all Florida soils are the richest in humus,

have not proved very satisfactory in most places. The rich humus of the keys, underlaid with coralline limestone, has given good results.

Moisture.—The pineapple requires considerable moisture for its successful growth, but there are only a few places in Florida where the lack of moisture can be considered a serious drawback. Some high ridges, however, such as are found in places along the Indian River, are too dry for the best growth of this plant. There is no doubt that the majority of the plantations would be greatly benefited by more moisture at times, but the effects of its scarcity are usually not very noticeable. An average yearly rainfall of about 100 inches is said to be typical for a pineapple country. The rainfall in Florida is in general about 50 or 60 inches.

METHODS OF CULTURE.

The climatic conditions existing in Florida have led to the practice of growing the plants under sheds, particularly in the case of fine varieties. At present there are about 100 acres of plants grown in this way in Florida. Some of these sheds cover from 7 to 10 acres. This method of growing, it is claimed, prevents excessive evaporation from the soil and plants, thus conserving the moisture; protects the plants from frosts, freezes, and winds; and prevents the fruit from sunburning.

When grown in this way, a larger percentage of the plants fruit within the usual time and the fruit is larger and of better quality. Usually the sheds are made about 7 feet high, to allow of perfect freedom in working. Some of the larger varieties, such as the Porto Rico, attain a height of 5 feet or more when grown under cover, and in such cases high sheds are necessary. The posts, which are usually of 3 by 3 inch pine, are set a short depth in the soil to give firmness, and are generally placed 9 by 14 feet apart. Stringers of 1 by 8 inch material are attached to the tops of these standards the 14-foot way. These support the cover of the shed and should be braced at each post. A narrower strip, placed below the main stringers, is nailed to the posts the 9-foot way to give greater firmness. The cover is made of 3 by 1 inch pine boards 18 feet long. These are nailed to the stringers, leaving between each board a 3-inch space. The method of growing under sheds is illustrated in fig. 62.

Most of the pineapples in the State, however, are grown by open culture; that is, are not covered with sheds. While growing the plants under sheds gives rather better results, open culture has also usually proved profitable. A field of the Porto Rico pineapples grown by the latter method is illustrated in fig. 63.

Irrigation is not as yet much practiced, and is not growing in favor. Those who have irrigating plants are usually inclined to believe that growing under sheds is preferable. Both methods, however, would probably be desirable, but would be too expensive for general use.

VARIETIES OF PINEAPPLES GROWN IN FLORIDA.

Of the many varieties of pineapples which are known, something over 25 have been introduced into Florida, and are now being cultivated there. Among these are many of the best varieties known, so that there is no lack of good varieties from which to select. The variety which is most widely cultivated in Florida, and which is spoken of as "the common" pineapple, is the Spanish, or Red Spanish. The fruits are of medium size, ranging from 2½ to 6 pounds, and usually sell at from 4 to 10 cents each. Formerly this variety was extensively cultivated in the West Indies, but there it has rapidly given way to other and better varieties.

In Florida, it is believed, the majority of intelligent planters are inclined to favor the cultivation of certain other varieties of the so-called fancy sorts, although many still claim that the Spanish is the best variety for general culture. The fruit of the Spanish is admitted by all to be inferior in quality to many others, but growers claim that it is the hardiest, is the easiest to cultivate, and best suited to varying conditions. This claim may be true, but in general it is as easy to raise a good fruit as a poor one, and the cost is about the same. Fruit grown in Florida can be placed in the New York market in from seven to ten days. Simmonds, in Tropical Agriculture, says that the average time of passage of pineapples from the Bahamas to London is from thirty-one to thirty-five days. As our best varieties are good shippers, enduring transportation to New York or Boston with little loss if properly handled, this can not be urged against the growing of the fine varieties.

Of other varieties, the Queen, or Golden Queen, is probably the most commonly grown, and is very good. The fruits are of medium size, weighing from 3 to 5 pounds, and usually sell at from 10 to 25 cents each.

Of the so-called fancy varieties, the Abbaka (Abbakacha), Smooth Cayenne, and Porto Rico are probably the most general favorites. The Abbaka is a tall, robust plant, with large, cylindrical, golden yellow fruits, which usually sell at from 30 to 40 cents each. The only serious fault with this variety is that the slips are so closely attached to the fruit that it is difficult to separate them without injuring the fruit. Most Florida planters, the writer believes, consider this the best variety grown.

The Smooth Cayenne is a large, broad-leafed variety, almost free from spines, a character which is of no little importance. The fruit is slightly conical, yellow when ripe, and of fine flavor. It weighs from 4 to 10 pounds, and sells usually at from 30 to 50 cents. This variety seldom produces slips, and this is a serious drawback to its general culture.

The Porto Rico is the largest and most robust plant and produces the largest fruit of any variety yet introduced and grown in Florida. The fruit usually weighs from 8 to 12 pounds, and packs from seven to nine to the half crate. Although rather coarse and sour, the fruit pays well, selling at from 50 cents to $1 each. This variety endures shipping very well, and forms abundant suckers and slips.

The Enville, or Enville City, Sugar Loaf, Ripley Queen, Lord Carrington, Moscow, Black Prince, Prince Albert, Giant Kew, etc., are other varieties grown, but with varying success. The Enville is a large fruit, of fine flavor, and is a general favorite. Unfortunately, it is a poor shipper, and is thus not generally planted. The Sugar Loaf, which Selmer says is the most prized of all varieties in the West Indies, has not met with general favor in Florida.

The Pinas de Cahuipa, which is said to be the favorite variety in Mexico, and which is largely cultivated in the State of Jalisco, has not yet been introduced into Florida, so far as the writer knows. It is claimed that not a trace of acid can be discovered in this fruit. The Ananassa Bracamorensis also has not yet, as far as known by the writer, been introduced. This variety, which was discovered a few years ago by Warscewicz at a small place known as Jean de Bracamoras, situated on the heights of Marañon, in South America, was first grown at Ghent, and from there introduced into England. The fruit is described as being very large, weighing 25 to 30 pounds, and of exceptionally fine quality and flavor.

METHODS OF PROPAGATION.

The pineapple is propagated principally by offsets from the parent plant. These offsets are of several kinds. Some of the axillary buds near the base of the parent plant push out vigorous sprouts, which are known as suckers. Two or more of these are formed, and when broken off and set out form new plants. The suckers which spring from buds below the soil are spoken of as "rattoons." These are usually left attached to the parent, and grow into new plants without transplanting. Good suckers usually fruit the first year after planting.

The so-called slips are produced from buds on the fruit stalk under the fruit. They are smaller than the suckers, but are more abundant, from five to fifteen being produced on a plant. If many plants are desired, they can be obtained by removing the slips immediately after the harvesting of the fruit. In this way from two to five new slips appear in the place where the first slip was broken off. Not more than two of these slips should be allowed to grow, and when these have attained sufficient size they may be broken off and planted. In general, however, slips should not be removed from the parent plant immediately after cutting the fruit, but should be allowed to remain until they mature. One may judge when to remove them by the turning brown of the stem under the leaves at the base. They should be

planted as quickly as possible after they mature. Slips fruit usually in twenty months after planting. Although they take more time than the suckers, they are said to produce better fruits, and, considering the expense involved, are in general preferred by planters.

The crowns produced at the apex of the fruit may be used to propagate the plant, but these require from two to five years to mature. As they are usually marketed with the fruit, however, they are seldom used in propagation. Seeds are occasionally produced by pineapples, but seedling plants require so long to mature (ten to twelve years) that they are used only when it is desired to secure new varieties.

PLANTING.

It requires less care to prepare the sandy soils of Florida for planting than is necessary with humus and clayey soils, which are liable to be lumpy. The trees and brush are cleared off and the stumps and roots grubbed out. The pine stumps, however, may be left in, as they rot in a few years. It is best not to burn the brush on the ground to be planted, as this destroys the productiveness of the soil by burning out the vegetable matter. After the land is cleared it is plowed and the trash again raked together and carted off. Some plant the pineapples immediately after clearing the land, while others wait for some months. It seems to make little difference when the land is planted, but when convenient it is probably best to let the land remain idle for a time after clearing, so that small limbs, weeds, etc., may be allowed to rot on the soil and form nutrition.

The plants are set in beds of varying size. It is important to have pathways at least every 25 or 50 feet to facilitate work in gathering the fruit. Some plant in long beds, about 14 feet wide, which are narrow enough to allow of cultivation without walking among the plants. In this way the leaves are saved from the injury which would otherwise unavoidably result. The distance left between the plants is important. Florida growers set them much closer than English planters. In Florida the Spanish variety is usually set from 18 to 20 inches apart each way, Queen 20 to 22 inches, Porto Rico 30 to 36 inches, and so on with the other varieties, according to size. The tendency is to decrease rather than increase the distance. The reason usually given for close planting is that the plants when close together support each other and prevent the fruit from falling over and becoming sunburned on one side. It is urged that pineapples do fully as well when set close, and, moreover, in this way the difficulty in keeping the weeds down is removed.

In general the methods of growing pineapples are different in Florida from those practiced in other pineapple countries. According to Selmer, it was formerly the custom in the Bahamas to plant the Spanish about 2 feet apart each way, but among the intelligent growers it is

now more common to plant them 3 feet apart. Selmer recommends planting them $2\frac{1}{2}$ feet apart in rows $3\frac{1}{2}$ feet apart. This would allow of cultivation with plows or cultivators, and is worthy the consideration of the growers in Florida, where labor costs so much. English planters also uniformly insist on giving the plants more space. In defense of the methods followed in Florida, however, it may be said that here planters do not depend on the natural richness of the soil, but on artificial fertilizers. In Florida soils the roots of the plants form in a dense cluster and do not spread to any great distance. Even in the closest planting, 18 inches square, the roots would probably not fully cover the space. Where artificial fertilization is used, the soil should be fully occupied to prevent loss. If crowding the tops produces no injury, but on the contrary is, as claimed, a benefit, there would seem to be no reason why close planting would not be profitable and successful.

To facilitate planting, the land is marked with a plow or "marker" such as is used in marking cornfields in the North. The marker may be made by taking a board 12 inches wide, 1 inch thick, and 12 feet long, and attaching to it, at the distances at which the plants are to be set, small runners similar to those on sleds. A tongue attached to the center completes the marker. If it is desired to have the plants set exactly the same distance apart—and this is important under sheds, where the space is very valuable—it is probably best to mark the rows by a line run the length of the bed. The distance which should intervene between the plants in the row is then easily marked with an apparatus like that represented in fig. 64. This has pegs $1\frac{1}{2}$ inches in diameter and about 5 inches long, which may be se at the desired distance. This instrument, which is easily made, used like a spade. Following the marking cord, guide the inst ment at one end of the row, putting the first mark where desir Then with the foot thrust the pegs into the soil. Continue down row in this way, each time placing one of the end pegs in the last l made, to guide the distance.

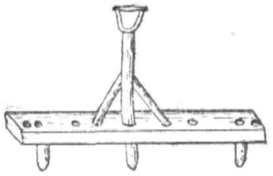


FIG. 64.—Instrument for marking a field for pineapples.

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Fig. 65, *a*, represents a sucker trimmed ready to plant, and *b* the base of a properly trimmed sucker. Many claim that it is quite necessary to trim the suckers high to prevent what may be called tangle root, otherwise roots start out under the bases of the lower leaves and do not penetrate into the soil, but are deflexed by the leaves and wind around the base of the plant, as shown in fig. 66. Many think that this is not at all injurious, and it must be admitted that in general little difference can be seen. However, the quite general occurrence of tangle root in connection with the pineapple blight, of which disease it is probably a symptom, leads the writer to think that it is not a desirable condition. The stem is usually larger above and below where the roots wind around it, which indicates that the winding prevents the stem from growing to its normal size. In general it

FIG. 65.—Pineapple suckers. *a*, pineapple sucker trimmed ready to set; *b*, base of a properly trimmed sucker.

would be well to strip off the leaves sufficiently to cut the base off above where roots have started.

The plants when properly trimmed are ready to set. They should be planted deep enough to give them a good hold upon the soil when rooted, so that they will not be blown over and injured. Usually slips should be set from 2 to 4 inches deep, and suckers from 3 to 5 inches, according to the size.

METHODS OF CULTIVATION.

In Florida the pineapple is cultivated almost wholly with the scuffle hoe, the ground being usually kept as nearly free from weeds as possible. Mulching has been used to some extent, but is not generally thought to be a good practice. The question of how to fertilize the soil to give the best growth is one of great importance to Florida pine-apple growers, but is at present little understood. Cotton-seed meal, [illegible] stems, and blood and bone are the fertilizers most

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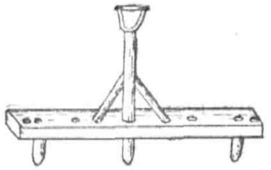

FIG. 64.—Instrument for marking a field for pineapples.

Planting is done principally in July, August, and September. The plants should be set out, however, as soon as possible after the fruit is removed, but the slips should be allowed to mature before they are removed from the parent plant. It is desirable to plant them early, so that they may have the advantage of as much of the summer rains as possible. Planting is frequently done in the later months also, but in this case the grower is not so sure to obtain good plants.

When removed from the parent plant, the slips and suckers usually have contracted, hard ends, covered with reduced leaves or bracts. It is a general practice in Florida, as well as in other pineapple coun-

tries, to strip off a number of the basal leaves and cut off a portion of this hard end before planting them.

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generally used. Although probably not the best fertilizers, they have an advantage in that they may be spread broadcast over the beds without injury to the plants. Cotton-seed meal is more used than any other fertilizer, and apparently gives good results. The chemical manurial elements, sulphate and muriate of potash, kainit, nitrate of soda, sulphate of ammonia, etc., burn the leaves. For this reason these can not safely be spread broadcast, but must be carefully put on the soil between the plants, care being taken not to get them on the leaves to any extent. Some growers claim that acid phosphates are very injurious, while others use them with apparently good results. Kainit and sulphate of potash are the forms of potash most generally used. The ammonia is commonly derived from cotton-seed meal, blood and bone, tobacco stems, nitrate of soda, and sulphate of ammonia; the phosphoric acid from cotton-seed meal, ground bone, and untreated phosphate rock. Where a complete fertilizer is used, from 1,500 to 2,000 pounds per acre is applied within the year or twenty months required for the development of the suckers or slips. It is put on at two or three applications and worked in by scuffle hoeing.

FIG. 66.—Tangle root of the pineapple.

After the plants have fruited they form suckers from the base. Those coming from below the soil (in this case called rattoons) are allowed to grow in order to continue the field without replanting, but the others are removed, to be planted in other fields. In this way fruiting and suckering may be continued on the same field for a number of years without replanting. With the Spanish variety this method will give good results for six or eight years, and to all appearances longer if proper care and proper fertilization are given. Some growers have fields considerably over eight years old. If the suckers are not largely removed, old fields become an almost impenetrable mat of plants. The plants even thus crowded,

which seems to be their natural mode of growth, are said to produce abundant and good fruit. In such fields all cultivation becomes impossible, the fertilizers used being spread broadcast without any attempt to work them in. In fields thus planted the decay of the old tops furnishes considerable nutrition.

GATHERING AND PACKING THE FRUITS.

The fruits ripen generally in May and June, but are usually gathered and shipped before fully mature. In *gathering*, the fruit of the Spanish variety is usually broken off, while the fancy kinds are cut or broken off, a long stem being left attached, which is cut off smooth after breaking. All possible care should be taken to avoid bruising. Before packing, the fruit is usually taken into the packing house and cooled. In the fancy sorts some careful packers coat the cut end of the stem with paraffin. The crowns are left attached and sold with the fruit. In Florida the fruit is packed in crates of a standard size, 12 by 20 by 36 inches. These are known as whole or barrel crates. For the fancy varieties half crates, 12 by 10 by 36 inches, are generally used. In packing, each fruit is usually wrapped separately in thin paper. *Shipping in bulk*, which is the usual method in the Bahamas and West Indies, is not practiced in Florida.

DISEASES OF THE PINEAPPLE.

"*Sanding.*"—The malady known as "sanding," which is caused by sand blowing into the apex of the plant and collecting around the young leaves, is of frequent occurrence. If the sand is not removed, it checks the growth of the plant. There is not much danger from sanding after the plants have become well rooted and are growing vigorously. It is a very common practice in Florida to put a handful of cotton-seed meal in the apex of the plant shortly after setting to prevent it from becoming sanded. The advantage of this is that the cotton-seed meal catches the sand, and when wetted by rain or heavy dews the mass becomes more or less cemented together. When the plant starts to grow, this mass is carried up on the ends of the new leaves, and is finally washed off onto the ground, where it serves as a fertilizer. This is a cheap and apparently a very effective preventive. If plants become sanded, they may be taken up and the sand removed, or the same result may be accomplished by directing, with considerable force, a small stream of water into the heart of the plant. Close planting, shedding, and wind-breaks are other preventive measures.

Long leaf, or spike.—The so-called long leaf, or spike, is very abundant in many places. Plants affected with it become stunted and dwarfed, and the leaves which develop are narrow and crowded. The cause of the disease is not known, but is probably primarily

due to improper soil conditions. The best thing to do, so far as at present known, is to destroy the plants which become diseased and plant others in their places.

Blight.—The pineapple blight, a symptom of which is a gradual withering of the ends of the leaves, is also a serious malady, and one which is at present little understood. It is particularly destructive to Queens and Porto Ricos and apparently affects all varieties to some extent. Different varieties usually assume different colors when attacked, the reddish color of the Queen becoming deeper, and the Porto Rico turning a pale yellow. Blight, as before stated, is frequently accompanied by tangle root, which is probably a symptom of this malady. Digging up blighted plants, pruning them thoroughly, removing the basal leaves, and cutting off the end of the stem with all the roots which have started, as in the case of preparing a sucker for planting, and finally transplanting, are said to restore the plant to health. Whether or not this treatment results in complete recovery of the plant has not yet been definitely proved.

FIG. 67.—Spots on the base of a pineapple leaf caused by the pineapple mite, or red spider (*Stigmæus*).

Pineapple mite, or red spider.—Probably the most serious disease of the pineapple in Florida is that caused by the minute red mite, or red spider (*Stigmæus* sp.), which works at the base of the leaves near the stem. They work on spots, which become slightly elevated and brownish, feeding around the edges of the spots and gradually extending them until the whole base of the leaf becomes diseased and the leaf dies. The characteristic spots resulting from the injury of these insects are shown in fig. 67. It is difficult to combat these insects, owing to the fact that they are usually below the soil and well protected by the closely overlapping leaves. No careful experiments have as yet been made toward conquering this pest, but sulphur wash poured or sprayed into the apex of the plant, or a small quantity of tobacco dust thrown into the apex, is said to have proved beneficial.

Mealy bug.—The mealy bug, which works principally on the leaves and stems, sometimes becomes troublesome by getting under the scales at the base and in the flower eyes of the fruit. They may probably be controlled by spraying with resin wash.

Several other diseases besides those above mentioned are known, but are not of common occurrence, and as yet cause only slight damage.

SMALL-FRUIT CULTURE FOR MARKET.

By William A. Taylor,
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It is the purpose of this paper to present in compact form the general principles upon which the successful culture of small fruits is founded. It is designed for beginners rather than for experienced growers, and is therefore largely devoted to points which the man without experience is likely to ignore, or at best to regard with insufficient attention. Some of the methods suggested may need modification to meet the needs of the individual grower, but it is believed that such changes as may be necessary will suggest themselves to the thinking cultivator who carefully considers his particular location and surroundings.

The growing of small fruits requires a comparatively large investment of capital per acre and also a better soil than is necessary for the production of most of the tree fruits. It is therefore better suited to the small farm, under the direct supervision of the owner, than to the large estate, whose proprietor cultivates by proxy. To balance the comparatively large capital required we have the fact that, aside from the value of the land and permanent improvements, the chief outlay is for labor, which may be done by the grower and his immediate family, while the returns are much quicker than from the tree fruits or the grape. In a few sections, so situated that large markets, either near or remote, are accessible, the culture of one or another of the small fruits may be profitably undertaken on a large scale, but these instances only serve to emphasize the fact that small fruit culture is primarily a homestead pursuit. The narrow bed or garden border of fifty years ago, enriched, dug, and weeded by hand, has developed into the field, fertilized, plowed, and cultivated by horse power, yet the requirements of the various species remain much the same, the methods of accomplishing the desired results alone differing. As practiced by advanced growers in the United States, the methods followed in the culture of small fruits are peculiarly of American development; while with the exception of the currant, the varieties extensively grown are of American origin.

The fruits to be considered are the strawberry, blackberry, raspberry, currant, and gooseberry.

CHOICE OF LOCATION.

No small-fruit plantation is likely to be profitable if located far from a market or convenient shipping point. In selecting a location special attention should be paid to the character of the roads, if the fruit must be hauled by wagon for any considerable distance. If railroad or steamboat transportation is to be depended on, the efficiency and enterprise of existing lines should be investigated, as the character of their service will be of great importance when fruit shipments begin.

In any given locality the most important consideration should be the selection of a site reasonably safe from killing frosts in spring. Away from the influence of bodies of water such sites are usually found on small plateaus or gentle slopes terminating in abrupt ravines or valleys where prompt and thorough cold-air drainage exists. Flat land, remote from open water and unbroken by ravines or hills, should always be regarded with suspicion, particularly if underlaid by a cold and badly drained subsoil. Bottom lands, in which admirable soil for small fruits is often found, are usually too uncertain in their fruit production, owing to frequent frost injury.

The soil requirements of the different species vary considerably, but all thrive in a moderately deep loamy soil that holds moisture well at all times without becoming soggy during protracted rainfall.

The exposure to be sought varies with the latitude, the climate, and the aim of the grower. If earliness is requisite to secure profitable prices, and the locality one in which late frosts are infrequent, a southern slope is preferable; if, on the other hand, a uniform and regular demand exists, regardless of a few days' difference in time of ripening, a gentle northern or northeastern exposure should be selected. In most localities, however, the matter of slope is of much less importance than that of comparative elevation of the site. It should lie higher than the adjacent land without being bleak, and should furnish a soil of at least fair fertility.

PREPARATION OF SOIL.

The selection of the proper preparatory crop is a matter of much importance. In general some hoed crop should precede the planting of any of the small fruits. With the strawberry at least two years of cultivation should intervene between well-established sod and the planting of berries, in sections where the white grub abounds. Corn or potatoes, well manured and kept free from weeds throughout the season by thorough cultivation, are good preparatory crops. In trucking regions almost any of the annual vegetables will do to precede small fruits. The objects to be attained are (1) to free the ground from seeds of annual weeds; (2) to eradicate established perennials of every sort, including grasses; (3) to get rid of noxious insect

larvæ, and (4) to leave the soil in that lively and mellow condition which the grower characterizes as "good tilth." If any portion of the field remains wet long after rains during any portion of the year, it should be drained before planting. In most soils and locations tile underdrains are preferable, though boards, poles, or stones are sometimes used to good advantage. If all of these are impracticable, land naturally wet can sometimes be made to yield fairly good crops by planting on ridges thrown up with the plow and depending upon open ditches to remove surface water.

Stumps, loose roots, and stones large enough to interfere with the cultivator should all be removed before the final plowing. The grower should bear in mind that thorough preparation of the soil will materially increase the probability of securing a good stand of plants, on the one hand, while it greatly decreases the amount of hand work necessary in hoeing and weeding, on the other. This is particularly true on new ground and on all soils of a clayey or tenacious character.

The preparatory plowing should be as carefully done as for a garden crop, and in most soils it should be as deep as possible without turning up much of the subsoil. Surface soils less than 8 inches deep should be plowed to their full depth. Where a compact or retentive subsoil is found, its stirring with a subsoiler will benefit the crop in most regions by affording prompter drainage and promoting deeper root growth. If the planting is not done until spring, most soils suitable for small fruits will be benefited by a deep fall plowing, followed by a shallower cross plowing as early in spring as the land is workable, or by thorough and repeated working with one of the numerous forms of disk or spading harrows now in use.

This should be followed by a lighter pulverizer or smoothing harrow before the soil becomes lumpy. The roller or plank clod crusher can sometimes be used to advantage, but if the soil be taken at the proper stage of dryness the treatment noted above will rarely fail to accomplish the desired result. Too much attention can hardly be bestowed upon this matter of soil preparation, yet it is often slighted by small-fruit planters. Errors in fertilizing, cultivating, or pruning can sometimes be corrected by subsequent good treatment, but deficient preparation can not be overcome during the existence of the crop.

MANURING.

Unless the soil is very rich from previous fertilizing, the crop will be largely increased by the application of well-rotted stable manure, say 20 tons to the acre, applied before the final plowing or thoroughly worked into the soil with a spading harrow. If stable manure is not obtainable, finely ground bone and muriate of potash can be profitably used on many soils. Nitrate of soda can sometimes be applied in moderation with profit. If the soil is of a sandy nature and known to be deficient in nitrogen, a preparatory crop of crimson clover will

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doubtless be advantageous in climates where this plant succeeds, or other leguminous crops may be grown and plowed in. Hard-wood ashes are excellent on most soils and, in general, commercial fertilizers rich in phosphoric acid and potash may be profitably used. The selection of the fertilizer that can be most profitably used on any particular soil must be determined by local experiment, however, and upon the very field in question unless tests have been made on similar soils in the immediate neighborhood.

It should be said that among growers who ship their fruit long distances there is an increasing tendency to favor commercial fertilizers rather than stable manure, on the ground that the fruit thus grown is firmer and of better carrying quality. This applies particularly to fruit grown in the humid climate of the South Atlantic and Gulf States, where most fruit plants incline to make a rank growth, which produces watery fruit, and where rains during the ripening season are frequent. A considerable gain results also from the absence of weed seeds from prepared fertilizers, these often proving very troublesome in fields enriched with stable manure.

PLANTING AND CULTIVATION.

The best time for planting small fruits is yet a disputed question, except in the North, where fall-set plants of most species are subject to winterkilling. There are few localities where spring planting is not the safer method, though often the soil can be more thoroughly prepared and the planting be more cheaply done in autumn than in spring. If done in autumn, in regions where the ground freezes to any considerable depth during winter, the newly set plants should be well mulched to prevent winter injury.

All planting should be in straight rows of equal distance apart. In the case of the bush fruits it is often advantageous to have the rows laid off both ways, so that the cultivator can be run in both directions, at least during the first season. If the land is hilly and inclined to wash, the rows should be laid around the hills, conforming to their curves, but on land reasonably level the rows should, if possible, run north and south and should be as long in that direction as the shape of the field will permit. Overcrowding of plants should be avoided, as fruit of large size is rarely produced by plants having insufficient food, air, and sunshine. If more than one variety of any fruit be planted, or if plants of the same variety be obtained from different sources, each lot should be separately planted and labeled. Failure to do this often leads to expensive uncertainty in later years when plants are desired for new fields or for sale. Many a careless or dishonest plant grower or dealer has escaped responsibility for misnamed or damaged stock through the inability of the planter to positively trace the plants to his establishment.

Plants should be promptly examined upon receipt, and should be at

should they be permitted to dry out or be left with roots exposed to the sun or to drying winds. If dry when received, they can often be freshened by placing the roots in water for a few hours. If the weather is dry at planting time, the "puddling" of the roots by dipping in a thin mud of clay and water to which fresh cow manure has been added will often go far toward insuring their growth.

Before setting out, each plant should be carefully examined, and all broken or decayed roots, leaves, or branches should be removed. Plants found diseased or infested with injurious insects should be promptly destroyed, unless the affected portions can be readily cut off and burned. The roots should always be placed in contact with fresh, moist soil, whether the planting be done with the hand or with dibble, spade, or other implement.

Cultivation should immediately follow planting, and should be repeated at frequent intervals during the spring and summer. The appearance of weeds should not be waited for, as the cultivation is for the crop rather than for the destruction of weeds. In general it should be shallow rather than deep, though when the soil becomes hardened by the impact of heavy rainfall or the tramping of berry pickers the grower should not hesitate to break it up by running a sharp cultivator, or even a light one-horse plow, to the depth of 3 or 4 inches between the rows. If the soil is properly prepared and the cultivation regularly kept up, this tearing up will rarely be necessary except after the harvesting of a crop of fruit. Provided the soil is in condition to work, once a week is not too frequent for the shallow cultivation of the small fruits during the growing season, and during the July and August drought that frequently prevails the surface soil should rarely remain unstirred longer than four or five days. Toward the end of summer, particularly on rich and moist soils, cultivation of the bush fruits should be less frequent, and it should entirely cease before the first frosts occur. The use of the hoe in small-fruit plantations should be avoided as far as possible, but when needed hoeing should be promptly done. With land in good tilth and clean at the start, with fertilizers free from grass and weed seeds, the necessity for the expensive and laborious use of the hoe as formerly practiced is greatly reduced. But in order to accomplish this the land must be free from clods, sticks, and stones, the cultivator teeth sharp, the horse steady and true, and the man active and careful.

PRUNING AND WINTER TREATMENT.

Where winters are severe enough once in four years to seriously injure unprotected bush fruits, mulching or laying down will often pay well. Much depends upon the character and cost of the material used, and its durability. Straw, unless clean thrashed and free from grass seeds, is a most productive source of future trouble to the grower. Forest leaves can be secured in sufficient quantity in some

localities to be available for use among the bush fruits. Where obtainable, pine needles also form an admirable mulch, and with a little care in removing can be used two or three times. Broken cornstalks that have been well tramped over in the barnyard are useful, and sorghum bagasse is utilized in some sections. In the colder and drier climate of the Upper Mississippi Valley the only sure protection for blackberries and raspberries is the laying down and covering of the canes. This is accomplished by digging away from one side of the plant, toppling it over with a fork, and wholly or partially covering the canes with earth from between the rows. This method involves staking or trellising the bushes when they are raised again in spring, but it is found profitable because of the insurance against crop failure which it affords. On most heavy soils water furrows should be run between the rows with a light one-horse or shovel plow late in fall, in order that surface water may be promptly removed during the winter months.

With the strawberry the only pruning needed will be the removal of superfluous runners. The raspberry and the blackberry, bearing their fruit almost exclusively on branches from canes of the previous year, are benefited by systematic pruning, while the currant and the gooseberry need it as urgently as do the tree fruits or the grape, if large fruit is the object sought.

Though sometimes subject to serious damage by insects and fungous diseases, the small fruits, as a class, are less injured by them than the tree fruits. Most of the serious troubles may be avoided by choosing vigorous and resistant varieties or by spraying with well-known insecticides and fungicides.[1]

VARIETIES FOR MARKET.

In the selection of varieties for planting, the best guide will always be local experience. If the grower aims to supply a home demand, he may often find it profitable to grow varieties which, because of lack of firmness, would be valueless for shipment. The published bulletins of the experiment stations afford much light on the subject by indicating in a general way what the behavior of varieties is in each State. These should be consulted, and also the reports of the State horticultural societies, many of which contain catalogues of the varieties known to succeed within their several districts. But most valuable of all will be found the experience of growers in the immediate vicinity. Their conclusions, though not always correct, are safest for the beginner, and he should only plant largely those varieties which they have found successful. The main planting should rarely consist of more than two varieties of each fruit, except in the

[1] See "Methods of Controlling Injurious Insects, with Formulas for Insecticides;" also "Treatment for Fungous Diseases of Plants," Yearbook of Department of Agriculture, 1894, pp. [illegible]

case of the strawberry, where four or five sorts ripening in succession may often be profitably grown. New and untried sorts, though highly commended elsewhere, should be planted in an experimental way only, for but a small percentage of the varieties introduced prove equal in value to the standard market sorts at the time of their introduction. The market to be supplied should be studied also, and if some one variety is found to be in special demand, that fact should be considered in making the selection from those known to succeed.

SELECTION OF PLANTS.

The selection of plants is a matter often slighted, even by growers who have long been engaged in the business, yet it is a most important item. The ideal method is to use such plants only as have been propagated from vigorous and productive individual plants of the desired variety. The owner of an established plantation can, by propagating from plants marked at fruiting time because of their superior vigor or productiveness, soon provide himself with plants much superior in these respects to those obtainable through commercial sources. But the beginner, with no fields to select from, must rely upon the fact that well-grown and accurately named stock is the best that he can get. He should insist that the stock furnished him be true to name, that it be free from injurious diseases and insects, that it be thrifty and from newly set fields, and that it be carefully dug and handled. Whenever practicable he should assure himself of the character of the stock by personal inspection of the plants during the growing season. For stock of this kind he should expect to pay a fair price. He can well afford to pay double the price usually charged for old bed stock of the same varieties. If the varieties desired are fairly healthy there, and reasonably true to name, he will usually find it best to buy as near home as the desired sorts can be found, though plants of all kinds are now shipped in good condition for long distances.

HARVESTING AND MARKETING.

Before the fruit begins to ripen, the size and style of package to be used should be decided on and a sufficient supply to market at least half of the estimated crop should be provided. The demands of different markets vary greatly, but in all of them a neat, clean package will outsell a poorly made or filthy one. The essentials are (1) that the packages shall be of the standard size in the markets to be supplied; (2) that they be as light as may be without sacrifice of sufficient stiffness and strength to withstand any ordinary pressure; (3) that they be neat, clean, and attractive in appearance. For the small fruits, except the red raspberry, the quart box or basket (packed in crates containing 16 to 64) is the supposed standard package in most markets, though degenerate sizes and forms of this cause a variation of 25 to

30 per cent in its actual capacity. Red raspberries are commonly marketed in pint cups or boxes (packed in crates), while currants are frequently sold in the climax basket so largely used in shipping grapes.

Where a home trade is supplied, the same packages, if carefully handled, can be used several times, but for shipment to any considerable distance the "gift" package seems destined to soon supplant the old "return" crate.

With packages provided, the necessity for some sort of packing house arises. This should be near the berries, and should be large enough to comfortably accommodate the packers and to shelter from sun and rain such quantity of picked fruit as is likely to accumulate at any one time. A flat-roofed shed, open to the north and boarded down from the top to near the ground on the other three sides, answers a very useful purpose. If a large area is planted, a more expensive building, with storage room above for packages, may be built with profit.

Enough hand carriers should be provided, so that each picker may deliver his load, receive credit for it by means of tickets or other simple method of keeping account, and receive an empty carrier in return without waiting for his own to be emptied. Some distinguishing mark should be placed upon each loaded carrier, however, in order that it may be traced to the picker at any time previous to the packing of the fruit in the crate. This is easily done by assigning to each picker a number and affixing to each carrier as it comes in an inexpensive tag marked with the picker's number. Inexperienced pickers need instruction when first placed at work, and watchful supervision for a day or two. Old hands often have to unlearn careless or slovenly habits acquired elsewhere, and in this respect are less satisfactory than new help. Neatness, thoroughness, and honesty must be insisted on, and after a picker is known to be reliable on these points his services are worth considerably more to the grower than before. Pickers should be instructed to assort fruit as they pick, or at least should be prohibited from placing decayed, unripe, or imperfect berries in the boxes with marketable fruit. All boxes should be as full as they can be packed in the crates without bruising the fruit, and the berries in the top layers should be placed by hand, so as to present an attractive appearance. It goes without saying that the fruit should be of uniform quality throughout the package if the grower hopes to build up a desirable reputation in his market.

Every package should be branded with his name, and this should be a sufficient guarantee of the uniformity of its contents. Such a brand will often insure against loss during gluts, and cause prompt sales at advanced prices when the conditions affecting demand and supply are normal.

STRAWBERRY.

The strawberry succeeds on a wide range of soil, but does best on a moist, sandy loam. It may be planted at any time of year if protected from sun and frost, but is commercially planted in early spring or in late summer. Only new plants, that is, those less than 1 year old, should be used, and these should be from the first sets rooted from runners. Distance between plants varies, but rows 4 feet apart, with a distance of 15 inches between the plants, requiring 8,712 plants per acre, may be taken as a fair average. Blossom buds should be removed from spring-set plants, as fruiting lessens plant growth. Runners should be allowed to root early in the season and until a row width of 15 to 18 inches is attained. Those formed later in the season should be cut or torn off with cultivators. To avoid tearing up rooted runners, always cultivate in the same direction; to prevent them from rooting, reverse the operation. Judicious thinning out of weak or crowded plants in the row is advisable. Select tested varieties, and if any are pistillate provide bisexual sorts blooming and ripening at same time, and, as nearly as may be, such as produce fruit similar in size, color, and appearance. Plant in separate rows in the proportion of one bisexual to three or four pistillate. Mulching usually pays if clean straw, etc., can be had at a low price. Injury to blossoms by frost can be lessened by pulling mulch up over them with light, broad, hand rakes during the preceding day and removing after the danger is past. In this connection, read the article on Frosts and Freezes in this volume.

Cultivation should cease from blooming time until fruit is harvested; otherwise should be as noted on page 287. For hoeing, a thin tool with both narrow and wide blades will be found advantageous.

The most difficult period in strawberry cultivation is that which immediately follows fruiting. Weeds and grass gain a foothold during the fruiting period, and the soil becomes hardened by the tread of pickers. Some growers prefer to plant a new field each year, in which case but a single crop of fruit is taken off, the plants being plowed under and followed by turnips, buckwheat, or some other quick-growing crop. Where land is high priced and the season long enough to mature a supplemental crop, this practice is to be commended, but in most localities it is found profitable to fruit strawberries at least two years.

In such case it is advisable to mow, dry, and burn the leaves and weeds as soon as the fruit is harvested. Some elements of fertility will be lost, but the destruction of injurious insects and fungi will compensate for this. If a durable mulch, like pine needles, has been used, this should be raked off and stacked for future use before the mowing is done. Immediately after the burning, two furrows should be thrown together, midway between the rows, with a light and sharp one-horse plow. Sometimes four furrows are needed to reduce the

width of the rows to 1 foot or less. This leaves all portions of the rows readily accessible to the hoe, which should follow the plow within a very few days. The frequent cultivation previously mentioned will in a short time level the ridge and reduce the space between the rows to a mellow condition favorable to the rooting of runners. Unless the soil is very rich and free from weeds, it will seldom pay to retain a strawberry field longer than two fruiting seasons.

Varieties succeeding over a wide range of soil and climate are: Bisexual—Michel, Wilson, Sharpless, Gandy; pistillate—Crescent, Warfield, Bubach, Haverland.

BLACKBERRY.

The blackberry can be profitably grown on lighter and drier soils than the strawberry, but requires frequent rains during the summer to mature its fruit. It should be planted very early in spring or in fall in the lower latitudes, plants being commonly secured as suckers from newly established fields, though plants grown from root cuttings are preferred by many growers. Where planted in hills for cultivating both ways, 6 by 6 feet (requiring 1,210 plants per acre) to 8 by 8 feet (requiring 680 plants per acre) is the proper distance, varying according to vigor and habit of variety. (See Pl. V.) If in rows, they should be about 7 feet apart, with plants 4 feet apart in the row, taking 1,556 plants per acre. Plants should be set 3 or 4 inches deep, with the tops cut back to 2 or 3 inches in length. Potatoes or other hoed crops may be grown between the blackberries the first year if well fertilized when planted. Not more than four or five new canes should be permitted to grow the first year, and after that only such as give evidence of being healthy and vigorous. Superfluous suckers should be treated as weeds. Most varieties yield better and larger fruit if the canes are pinched back at the height of 18 to 24 inches in summer. The branches, should there be any, are cut back one-third or more in the spring. Old canes may be cut out at any time after fruit is picked. This is generally done in spring. Varieties not subject to rust or other fungous disease should be chosen. The following are chiefly grown for market: Early Harvest, Wilson, Snyder, Erie, Taylor, Ancient Briton. The first two varieties named need winter protection wherever the peach is subject to frequent injury by cold. With good treatment, a well-established plantation may be expected to continue profitable for six or eight years, though much depends upon the effect of severe winters.

RASPBERRY.

The three types of this fruit—red, black, and purple—differ considerably in their requirements.

The red raspberries proper, and of these the market grower need concern himself only with the varieties of our native species, succeed

FIG. 1.—EARLY HARVEST BLACKBERRY, SINGLE-WIRE TRELLIS, BENTON HARBOR, MICH.

FIG. 2.—EARLY HARVEST BLACKBERRY, HILL SYSTEM, FALLS CHURCH, VA.

through a much wider range of soil and climate than the blackcaps. Both do best, however, on a well-drained but moist, rich clay loam. Both fail on thin sandy or gravelly soils, unless highly fertilized and irrigated during the fruiting season.

The reds are commonly grown from 1-year-old suckers, though sometimes from root cuttings, and are usually planted in rows 6 feet apart, with plants 4 feet apart in the row, taking 1,815 plants per acre. As with blackberries, superfluous suckers should be promptly removed with the hoe. With many varieties fully half of the suckers that spring up should be thus destroyed each year. Planting is done in the same manner as with the blackberry, in either fall or spring. Plants may be moved short distances, as on the same farm, at any time during spring or early summer, provided damp, cloudy weather is selected for the work. Pruning is commonly limited to heading back canes to the extent of one-third of their growth, in spring before the leaves start. At the same time the old canes are removed, if this has not previously been done. The varieties most widely grown and successful are Hansell, Marlboro, Cuthbert,[1] and Turner.

The blackcaps are less popular than the reds for eating fresh, but are considerably grown for canning and in recent years for evaporating. They endure shipment well in the fresh state, and by evaporating may be grown with profit at a greater distance from transportation lines than other small fruits.

Plants are obtained from rooted tips and should be set out the same as the reds, with rows running both ways. The canes should be pinched back on reaching the height of 18 to 24 inches, and unless plants are desired for new plantations or for sale the tips should not be allowed to root. Spring pruning should consist in the removal of old canes and the cutting back of branches to a length of 12 to 18 inches.

The varieties most widely grown are Ohio, Gregg, Nemaha, and Doolittle.

The purple class has never become very popular in market, and only one variety, Shaffer, is now extensively grown. The treatment required is similar to that advised for the blacks, but owing to its larger growth the Shaffer should not be planted closer than blackberries.

Raspberries rarely yield more than three or four profitable crops from a single planting.

CURRANT AND GOOSEBERRY.

These allied species require much the same soil and treatment. Both fail on dry or poor soils, and both thrive on moist clayey or sandy loams. They are essentially cool-climate plants and south of the Ohio and Potomac rivers do best if given partial shade. These

[1] In some sections the Golden Queen, a yellow variety that originated as a sport from the Cuthbert, is grown for near markets.

may be planted in fall with impunity on any soil suited to their growth, and need no winter protection in most latitudes. The site selected should be one where snow does not accumulate to a great depth, for this breaks down the branches during alternate thaws and freezes, doing much damage to the bushes.

Plants 2 years old with good roots, grown from cuttings, should be chosen. Most of the top should be cut away unless symmetrical, and in any case the leading branches should be headed back. They are essentially low-headed trees, and should be treated as such. If planting be delayed until spring, it must be done very early, as these are among the first to start growth. Four by six feet, requiring 1,815 plants per acre, is about the right distance apart. Cultivation must be shallow, as these are surface-rooting plants. On some soils they are frequently grown profitably by substituting a heavy mulch for cultivation.

Pruning should be done in fall or very early in spring, and should consist in the thinning out of weak and old branches, and the heading back of those making a vigorous growth. The markets are seldom overstocked with these fruits, and though the maximum price per quart is often less than for other berries, they are likely to net the grower as much in the long run. The gooseberry, which is chiefly marketed in this country in the green state, is perhaps the small fruit best suited to planting for market by the general farmer, as it interferes less with ordinary farm operations than any other. The fruit is in marketable condition for a longer time, and can be picked with the minimum of outside labor. By protecting the hands and wrists with leather gloves the green berries may be stripped from the bushes into pails with little injury to either fruit or bush. The fruit is then quickly cleaned of leaves and rubbish by running through a common fanning mill, which completes its preparation for market.

The varieties of currants commonly grown for market are: Red—Red Dutch, Cherry, Prince Albert, Victoria, Fay; white—White Grape, White Dutch; black—Black Naples.

The gooseberries most widely grown are Houghton, Pale Red, and Downing, all of American origin and parentage, though in some localities Industry, an English variety, little subject to mildew, is profitably grown.

THE CAUSE AND PREVENTION OF PEAR BLIGHT.

By M. B. Waite,
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There is probably no disease of fruit trees so thoroughly destructive as pear blight, or fire blight, which attacks pears, apples, and other pomaceous fruits. Some diseases may be more regular in their annual appearance, and more persistent in their attacks on the fruits mentioned, but when it does appear pear blight heads the list of disastrous maladies. Again, no disease has so completely baffled all attempts to find a satisfactory remedy, and, notwithstanding the great progress made within the last ten years in the treatment of plant diseases by spraying and otherwise, pear blight has until recently continued its depredations unchecked. It is now known, however, that the disease can be checked by simply cutting out the affected parts. This was one of the first methods tried in endeavoring to combat the disease, but came to be generally regarded as worthless. The remedy which will be discussed in this paper is, in a general way, so similar to the old one that at first it may be difficult to see that anything new has been discovered. In the process now proposed, however, there are three vital improvements, namely, the thoroughness and completeness with which the work is carried out, the time when the cutting should be done, and a thorough knowledge of the disease so as to know how to cut.

The method of holding the blight in check was discovered through a careful scientific investigation of the life history of the microbe which causes it. The investigations were carried on in the field and laboratory, and extended over several years. In the short account which follows no attempt will be made to enter into the details of the work, nor to introduce all the evidence to prove the various statements, but simply to give such points as will enable the reader to intelligently carry out the method advocated.

WHAT IS PEAR BLIGHT?

Pear blight may be defined as a contagious bacterial disease of the pear and allied fruit trees. It attacks and rapidly kills the blossoms, young fruits, and new twig growth, and runs down in the living bark to the larger limbs, and thence to the trunk. While the bacteria themselves rarely kill the leaves, at most only occasionally attacking the stems and midribs of the youngest ones, all the foliage on the

blighted branches must of course eventually die. The leaves usually succumb in from one to two weeks after the branch on which they grow is killed, but remain attached, and are the most striking and prominent feature of the disease.

The most important parts of the tree killed by the blight are the inner bark and cambium layer of the limbs and trunk. Of course, when the bark of a limb is killed, the whole limb soon dies, but where the limb is simply girdled by the disease, it may send out leaves again the next season and then die. All parts of the tree below the point reached by the blight are healthy, no more injury resulting to the unaffected parts of the tree than if the blighted parts had been killed by fire or girdling.

Blight varies greatly in severity and in the manner in which it attacks the tree. Sometimes it attacks only the blossom clusters or perhaps only the young tips of the growing twigs; sometimes it runs down on the main branches and trunk; and again it extends down only a few inches from the point of attack. The sudden collapse of the foliage on blighted branches has led many to believe that the disease progresses more rapidly than it really does. It rarely extends farther than 2 or 3 inches from the point of attack in one day, but occasionally reaches as much as 1 foot.

It is an easy matter to determine when the disease has expended itself on any limb or tree. When it is still progressing, the discolored, blighted portion blends off gradually into the normal bark, but when it has stopped there is a sharp line of demarcation between the diseased and healthy portions.

CAUSE OF THE DISEASE.

Pear blight is caused by a very minute microbe of the class bacteria. This microbe was discovered by Prof. T. J. Burrill, in 1879, and is known to science as *Bacillus amylovorus*. The following are the principal proofs that it causes the disease: (1) The microbes are found in immense numbers in freshly blighted twigs; (2) they can be taken from an affected tree and cultivated in pure cultures, and in this way can be kept for months at a time; (3) by inoculating a suitable healthy tree with these cultures the disease is produced; (4) in a tree so inoculated the microbes are again found in abundance.

LIFE HISTORY OF THE MICROBE.

Blight first appears in spring on the blossoms. About the time the tree is going out of blossom certain flower clusters turn black and dry up as if killed by frost. This blighting of blossoms, or blossom blight, as it is called, is one of the most serious features of pear blight. One of the most remarkable things about this disease is the rapidity with which it spreads through an orchard at blooming time. This peculiarity has thrown much light on the way the microbes travel about,

which they do quite readily, notwithstanding the fact that they are surrounded and held together and to the tree by sticky and gummy substances. They are able to live and multiply in the nectar of the blossom, from whence they are carried away by bees and other insects, which visit the blossoms in great numbers for the honey and pollen. If a few early blossoms are infected, the insects will scatter the disease from flower to flower and from tree to tree until it becomes an epidemic in the orchard. We shall see later how the first blossoms are infected. From the blossoms the disease may extend downward into the branches or run in from lateral fruit spurs so as to do a large amount of damage by girdling the limbs. Another way in which the blight gains entrance is through the tips of growing shoots. In the nursery, when trees are not flowering, this is the usual mode of infection. This is often called twig blight, a good term to distinguish it from blossom blight, provided it is understood that they are simply different modes of attack of the same disease.

CONDITIONS AFFECTING THE DISEASE.

The severity of the attacks, that is, the distance which the blight extends down the branches, depends on a number of different conditions, some of which are under the control of the grower. It is well known, however, that the pear and quince are usually attacked oftener than the apple. Some varieties of pears, like Duchess and Keiffer, resist the disease much better than others, such as Bartlett and Clapps Favorite. It may be stated in a general way that the trees most severely injured by blight are those which are healthy, vigorous, well cultivated, and well fed, or, in other words, those that are making rapid growth of new, soft tissues. Climatic conditions greatly influence the disease, warm and moist weather, with frequent showers, favoring it; dry, cool, and sunny weather hindering it, and very dry weather soon checking it entirely.

The pear-blight microbe is a very delicate organism and can not withstand drying for any length of time. In the blighted twigs exposed to ordinary weather it dries out in a week or two and dies. It causes the greater part of the damage in the month or two following blossom time, but twig blight may be prevalent at any time through the summer when new growth is coming out. In the nursery severe attacks often occur through the summer. In the majority of cases, however, the disease stops by the close of the growing season. At that time the line of separation between the live and dead wood is quite marked, and probably not one case in several hundred would be found where the diseased wood blends off into the healthy parts and the blight is still in active progress. In the old, dried bark, where the disease has stopped, the microbes have all died and disappeared.

It has been claimed that the blight microbe lives over winter in the soil, and for a long time the writer supposed this to be the case, but

after careful investigation the idea was abandoned, for in no instance could it be found there. Unless the microbes keep on multiplying and extending in the tree, they soon die out. This is a very important point, for it affords opportunity to strike the enemy at a disadvantage. In certain cases the blight keeps up a sort of slow battle with the tree through the summer, so that at the close of the season, when the tree goes into a dormant condition, active blight is still at work in it. This is also true of late summer and autumn infections. In these cases the blight usually continues through the winter. The germs keep alive along the advancing margin of the blighted area, and although their development is very slow, it is continuous. Probably the individual microbes live longer in winter. At any rate, the infected bark retains its moisture longer, and generally the dead bark contains living microbes during a much longer period than it does in summer. It has already been found that this microbe stands the cold well. Even when grown in broth in a warm room they may be frozen or placed in a temperature of 0° F. and not suffer.

When root pressure begins in early spring the trees are gorged with sap. Under these favorable conditions the microbes which have lived over winter start anew and extend into new bark. The new blight which has developed in winter and spring is easily recognized by the moist and fresh appearance of the blighted bark, as contrasted with the old, dead, and dry bark of the previous summer. The warm and moist weather which usually brings out the blossoms is particularly favorable to the development of the disease. At this time it spreads rapidly, and the gum is exuded copiously from various points in the bark and runs down the tree in a long line. Bees, wasps, and flies are attracted to this gum, and undoubtedly carry the microbes to the blossoms. From these first flowers it is carried to others, and so on till the blossoms are all killed or until the close of the blooming period. Even after the blooming period it is almost certain that insects accidentally carry the blight to the young tips and so are instrumental in causing twig blight also. The key to the whole situation is found in those cases of active blight (comparatively few) which hold over winter. If they can be found and destroyed, the pear-blight question will be solved, for the reason that without the microbes there can be no blight, no matter how favorable the conditions may be for it; to use a common expression, there will be none left for seed.

TREATMENT FOR PEAR BLIGHT.

The treatment for pear blight may be classed under two general heads: (1) Methods which aim to put the tree in a condition to resist blight or to render it less liable to the disease; and (2) methods for exterminating the microbe itself, which is of first importance, for if carried out fully there can be no blight. The methods under the first head must unfortunately be directed more or less to checking the

growth of the tree, and therefore are undesirable except in cases where it is thought that the blight will eventually get beyond control in the orchard. Under the head of cultural methods which favor or hinder pear plight, as the case may be, the following are the most important:

Pruning.—Pruning in winter time, or when the tree is dormant, tends to make it grow and form a great deal of new wood, and on that account it favors pear blight. Withholding the pruning knife, therefore, may not otherwise be best for the tree, but it will reduce to some extent its tendency to blight.

Fertilizing.—The better a tree is fed the worse it will fare when attacked by blight. Trees highly manured with barnyard manures and other nitrogenous fertilizers are especially liable to the disease. Overstimulation with fertilizers is to be avoided, especially if the soil is already well supplied.

Cultivation.—The same remarks apply here as in the case of fertilizing. A well-cultivated tree is more inclined to blight than one growing on sod or untilled land, although the latter often do blight badly. Generally good tillage every year is necessary for the full development of the pear and quince trees, and is more or less so for the apple in many parts of the country, but the thrift that makes a tree bear good fruit also makes it susceptible to blight. Check the tree by withholding tillage, so that it makes a short growth and bears small fruit, and it will be in a better condition to withstand blight than it would were it cultivated. In cases where thrifty orchards are attacked by blight and threatened with destruction, it may often be desirable to plow them once in the spring and harrow soon after the plowing, to plow them only, or to entirely withhold cultivation for a year, mowing the weeds and grass or pasturing with sheep. A good way is to plow the middle of the space between the rows, leaving half the ground untouched.

Irrigation.—In irrigated orchards the grower has the advantage of having control of the water supply. When such orchards are attacked, the proper thing to do is to withhold the water supply or reduce it to the minimum. Only enough should be supplied to keep the leaves green and the wood from shriveling.

Extermination of the blight microbe.—We now come to the only really satisfactory method of controlling pear blight—that is, exterminating the microbe, which causes it, by cutting out and burning every particle of blight when the trees are dormant. Not a single case of active blight should be allowed to survive the winter in the orchard or within a half mile or so from it. Every tree of the pome family, including the apple, pear, quince, Siberian crab apple, wild crab apple, the mountain ash, service berry, and all the species of Cratægus, or hawthorns, should be examined for this purpose, the blight being the same in all. The orchardist should not stop short of

absolute destruction of every case, for a few overlooked may go a long way toward undoing all his work. Cutting out the blight may be done at any time in the winter or spring up to the period when growth begins. The best time, however, is undoubtedly in the fall, when the foliage is still on the trees and the contrast between that on the blighted and that on the healthy limbs is so great that it is an easy matter to find all the blight. It is important to cut out blight whenever it is found, even in the growing season. At that time of year, however, it can not be hoped to make much headway against the disease, as new cases constantly occur which are not sufficiently developed to be seen when the cutting is done. In orchards where there are only a few trees, and the owner has sufficient time to go over them daily, he will be able to save some which would otherwise be lost. However, when the trees stop forming new wood, the campaign should begin in earnest.

Of course, the greater part of the blight can be taken out the first time the trees are gone over. If this be in midsummer, the trees should all be again carefully inspected in the autumn, just before the leaves shed, so as to get every case that can be seen at that time. After this a careful watch should be kept on the trees, and at least one more careful inspection given in spring before the blossoms open. It would doubtless be well to look the trees over several times during the winter to be certain that the blight is completely exterminated. In order to do the inspecting thoroughly it is necessary to go from tree to tree down the row, or in the case of large trees to walk up one side of the row and down the other, as in simply walking through the orchard it is impossible to be certain that every case of blight has been cut out.

The above line of treatment will be even more efficacious in keeping unaffected orchards free from the blight. A careful inspection of all pomaceous trees should be made two or three times during the summer and a sharp lookout kept for the first appearance of the blight. It usually takes two or three years for the disease in an orchard to develop into a serious epidemic, but the early removal of the first cases will prevent this and save a great deal of labor later and many valuable trees.

In doing this work it must be remembered that success can be attained only by the most careful and rigid attention to details. Watch and study the trees, and there is no question that the time thus spent will be amply repaid.

GRASS GARDENS.

By F. Lamson-Scribner, B. Sc.,
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WHAT IS A GRASS GARDEN?

Gardens devoted exclusively to grass culture and experiment are called grass gardens. Usually their object is to exhibit and test the qualities of grasses useful or possibly useful for forage, and other plants used for this purpose, the clovers, vetches, etc., have generally been given a place in the gardens with them. These gardens are museums of living plants, and as such they are particularly interesting, as they contain the plants which form the basis of agricultural pursuits, and are of the greatest importance, directly or indirectly, to man. One of the first and most celebrated grass gardens was that conducted by Mr. George Sinclair, under the patronage of the Duke of Bedford, early in the present century. Within the last few years grass gardens have multiplied, both in Europe and in this country; here particularly, because of the establishment of the State experiment stations, many of which make the subject of grass culture an important feature of their work.

Grasses and forage plants exist in great variety, and possess great diversity of character. Some are coarse in growth and harsh in texture, while the growth of others is fine and tender. Some possess the qualities required for making hay; others have characteristics which adapt them for grazing. Some possess good turf-forming habits; others will make no turf. Some thrive best under the heat of midsummer; others flourish only in the cooler seasons of the year. Some present a scanty vegetation at best; others a vigorous and abundant growth. All these points and much besides may be observed and studied in the grass garden.

RECOGNITION AND COMPARISON OF SPECIES.

An opportunity is afforded for the comparison of one kind with another, and for noting their relative merits for special purposes. We may also learn to know all plants advertised by seedsmen, and to judge whether the varieties advertised are those we would wish to propagate. Again, we may learn to know the native grasses, for these should not be omitted from the garden. They should always have a place, not only for the reason here suggested—that of becoming

familiar with their appearance and learning to know them—but because they may exhibit under cultivation qualities of usefulness little suspected from what they may exhibit in their native stations. In a grass garden, however limited in extent, one will soon come to recognize by their leaves alone the several species which he may have growing in it. He will not have to wait, as does the botanist, for the plant to come into flower and mature before he can analyze it. The leaves of the several species have their peculiarities—slight differences in shape or size, or in the pointing of the tips, but more markedly in the variety of their colors—which the close observer will soon learn to detect and associate with the several forms (fig. 68).

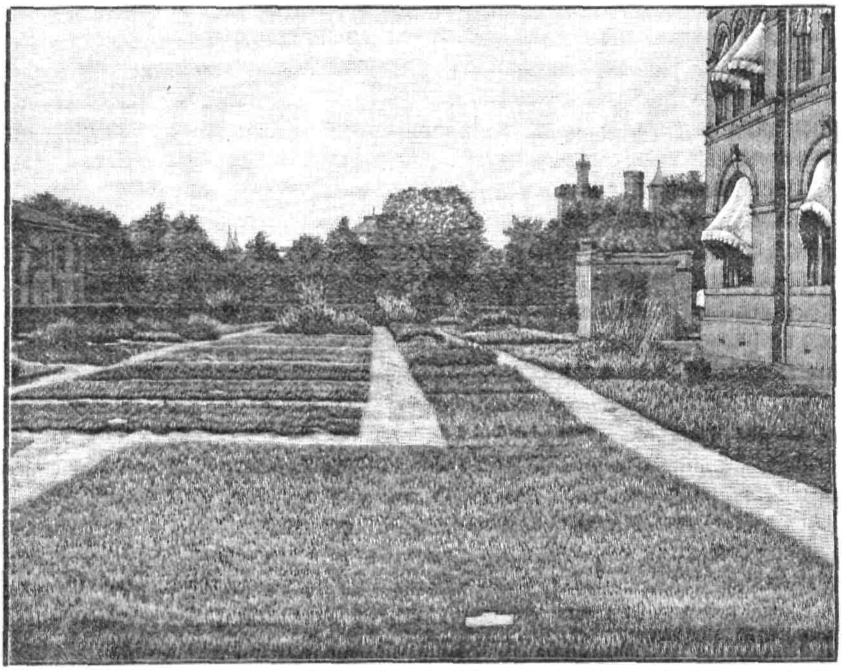

FIG. 68.—Grass garden at the U. S. Department of Agriculture. Plat of buffalo grass in the foreground. (Engraved from photograph.)

The gardener will, if his heart is in the work, soon discover individual peculiarities in the plants he cultivates, and detect variations which may be found to be as fixed or permanent as those which limit species. He may even become attached to individual plants which he has thus discovered, and which present to him qualities of special excellence, either for the formation of turf, which is what we most need, or for production of a superior hay. There are certain grasses which exhibit more markedly than others these small yet important differences. This is true of Kentucky blue grass, redtop, and some of the species of fescue. These are grasses which have a wide

geographical range, grow on a great variety of soils, and in their habitats present marked variations in size and general habit of growth, in the length, breadth, and color of their leaves, and to some extent also in their flowers. The variations appear, however, chiefly in the vegetative parts—roots, stems, and leaves—and it is these which give the plants their value in agriculture. By special selection of seed or, better still, rooted plants, these individual peculiarities may become fixed and extended by propagation, and "improved varieties" obtained, as in the case of Indian corn, wheat, and other plants. These are some of the things which may be studied and learned in a grass garden of the simplest form.

THE BOTANIST'S INTEREST IN THE GARDEN.

To the botanist a grass garden may serve many a useful purpose. In it the grasses of all countries may be grown and so arranged in their natural tribes and subdivisions, giving to each a space proportionate to the number of species which it contains, that relationships may be studied to the best advantage. In no other way can one more readily acquire a knowledge of the grass family as a whole, taking it in at a glance, so to speak, than in a garden thus systematically arranged. He is presented with an opportunity to study individual characters of special interest to him, to test the permanency of these peculiarities, as well as the validity of species or varieties. It is unfortunate that botanists who make a study of grasses can not visit the countries where each and every species grows, but this is impossible; one is forced to depend upon the collections of many collectors who are not always botanists, and who do not always gather material in the best shape for study. Not quite so good as seeing the grasses in their native habitat, but far better than viewing dried material alone, is the possession of a grass garden, where one may at least see and study the living plants themselves, although they may be in artificial surroundings. There is much to learn from the living plant, which never appears in the dead herbarium specimens, and it is very likely that the study of living material in the garden will lead to many changes or modifications of opinions and conclusions drawn from dried and mounted specimens. The grass garden affords its possessor an opportunity to make herbarium specimens which can be sent to those less fortunate in this possession, and which may also be used in making exchanges with other botanists. Likewise seeds may be obtained from the grasses grown in the garden, and these may be distributed to other gardens or botanical institutions for the purpose of diffusing a knowledge of these plants through their multiplication at different points.

SELECTION OF GRASSES FOR PARTICULAR LATITUDES.

The behavior of the grasses during the various seasons of the year will determine in some degree the latitude to which they are best

adapted. Those which grow and thrive under the direct rays of the summer sun suggest an adaptability to summer pasturage or successful cultivation in more southern latitudes. Those which make growth only during the cooler seasons of the year, remaining green through the winter months, suggest usefulness in a cooler region or value for winter pasturage in the South, where such grasses are much needed. Again, a protracted period of drought or a season of excessive moisture may bring out or exhibit qualities in the grasses of the garden equally important to know. There are regions in this country in which the climate, generally speaking, is moist and cool. There are others, of equal or greater area, of little rainfall and light dews. Those grasses which may have been cultivated showing a marked resistance to long periods of dryness are those most likely to prove successful in cultivation in the dryer portions of our territory.

THE GRASS GARDEN AS AN EXPERIMENT STATION.

So far, mention has been made only of what may be learned in a garden conducted upon the simplest plan. We may go further, and make an experiment station out of it. Usually the gardens are of limited extent, because of the care required to maintain them in good condition, and the soil of the garden is practically uniform throughout. The plat assigned to each species is small, and with a little labor we can change the soil of these plats and thus test the adaptability of a given species to various soils of similar humidity. In the same way we may test the various fertilizers, having a number of plats of the same species all fertilized in different degrees. If it is desired to test the productiveness of any given variety, it is, of course, a simple matter to do this by the ordinary process of harvesting a specified area and weighing the product. Opportunity is also afforded of procuring specimens for chemical analysis during different periods of growth. If it is desired to test the turf-forming capacity of any of the grasses cultivated, this may be done by close and frequent clippings with the lawn mower, and occasional rollings. Turf of excellent quality can thus be produced from a number of grasses, and if the work is well and carefully done from the beginning, a turf garden of exceeding attractiveness may be formed. It is surprising what a large number of grasses will submit to this treatment. Many species ordinarily regarded as poor turf formers will, when properly handled, make excellent turf. For convenience, the grasses which it is desired to test as turf formers should occupy a part of the garden by themselves, or, better still, should have a place entirely separate from the garden in which the grasses are allowed to go to seed.

To give this work its highest economic value, cooperative experiments should be made. The grasses cultivated at one station should be grown also at another in a different State, or in regions where the climatic and soil conditions are markedly different. Under our system

of State experiment stations it is possible to do this work, where cooperation can be secured, under the most favorable conditions. In all these experiments too hasty conclusions should be avoided.

LAYING OUT THE GARDEN.

Much of the success of a grass garden depends upon the location and soil where it is to be established. The garden should have a gently sloping surface, it matters little in what direction. In the Southern States a northern trend is best, while in the Middle and Eastern States an eastern slope is most desirable. If possible, the land selected should be in native turf, and artificially, if not naturally, well drained. Land in native turf is most suitable, for the reason that it is likely to be most free from weed seeds, and no fertilizer will equal this turf when plowed under. The plowing should be done in August or September, and by cross plowing and frequent harrowings in the spring the land should be made as fine as possible, and any additional fertilizer that may be required should be applied. In laying off the garden, it is customary to adopt rectangular plats of a definite fraction of an acre, and this is perhaps the best way where it is desired to estimate the product of the several species cultivated. The plats or beds should not be raised above the walks. Walks may be entirely omitted in gardens devoted to turf culture. If the beds should run in lines or bands, they should extend at right angles to the slope.

A more pleasing garden can be obtained by breaking up the rectangular plan to some extent, introducing broader or narrower beds, or longer and shorter ones, or occasionally allowing them to take some other shape. In the grass garden at the Department of Agriculture there is upon each side of the greater length a double series of beds or plats designed for the growth of native and cultivated grasses to be allowed to come into flower. Inside of these bands there is a narrow line of plats in which are grown various fodder plants—clovers, vetches, lupines, etc.—which do not belong to the grass family. Extending lengthwise through the center is a series of larger beds, in which are cultivated those grasses which are known or supposed to be good formers of turf. These are kept closely mown, and are rolled occasionally. It is possible to water any part of the garden by artificial means. In the illustration of the garden here presented (fig. 68), some idea of its plan may be gathered. The middle plat in the foreground is composed of the true buffalo grass of the plains, live roots of which were planted here late in the spring, and before autumn a very close, compact turf was formed, making a pure culture entirely free from weeds or other grasses. It is necessary to cultivate the grasses in pure cultures if we wish to learn all the facts relative to their individuality. Of course, it may sometimes be desirable to test the growth and permanence of known mixtures, or to grow two or three varieties

together in order to determine which will prove the most vigorous or will survive the longest. It is hardly possible to grow pure cultures over considerable areas without the expenditure of more time and money than the case would probably warrant. If seed is used, whether procured from a seedsman or gathered by hand, it should be most

FIG. 69.—Bouquet of grasses from the grass garden. Includes orchard grass, Texas blue grass tall fescue, Schrader's brome grass, tall meadow oat grass, Kentucky blue grass, redtop, English foxtail, annual vernal grass, rye grass, etc. (From photograph.)

carefully examined, and, after the removal of all foreign ingredients, planted in drills, not too thickly.

HOW TO STOCK A GRASS GARDEN.

This method of planting is necessary to the destruction of the weeds and other grasses which may spring up the first season, and which

can thus be recognized. In the fall the plants thus secured from seed can be transplanted and made to cover the area desired for their future culture. Live roots or sods are preferable to seeds, for then we are sure of what we have, and the material can be set out at once where desired. If we are simply making a botanical collection, the sods or live roots can, of course, be collected by anyone who has a botanical knowledge of plants. When, however, we desire to get beyond this and secure the best plants, it is necessary to go over the fields and pastures in early spring or during an open winter and collect those individual specimens which we may find either exhibiting qualities superior to their associates or marked by characteristics, however derived, which it may seem desirable to perpetuate.

Of course, a grass garden may be stocked, and abundantly stocked, by seed procured from reliable seedsmen. Good seed, true to name, may be so obtained, and much may be learned from plants produced as indicated above; but more is to be learned, and perhaps more valuable knowledge gained and more good accomplished, by carefully gathering the seeds of our native grasses now unknown to agriculture, or only prized by a farmer here and there who may be fortunate enough to possess a native patch sufficiently large to attract his attention and yield him a choice though limited crop.

NATIVE GRASSES THE BEST.

The cultivation of these native grasses in a garden may seem almost trivial where, as in many cases, it is not possible to procure much more than a pinch of seed, or to give to any one of them much space; but all the cultivated grasses and clovers of which we know the history have been grown in a small way at first, and even some of the varieties of wheat now sown over square miles of our territory were first grown in this limited way. We have better grasses and a greater variety of them, native to our soil, than we can ever get from Europe, and it will not be necessary to grow them ten or twenty years or more in order that they may become acclimated, as is the case with those imported. There are sixty native species of clovers found in the United States; there are more than sixty kinds of blue grass, distinct botanical species; there are twenty or more good grazing grasses related to the buffalo grass; there are fourscore or more of native lupines, and twoscore vetches, which have yet to be tried in our agriculture; and then there are the brome grasses and meadow grasses and pasture grasses and hay grasses, almost numberless, suitable to every kind of soil and rock formation and climate. And of all this wealth of kinds, the natural heritage of our country, hardly more than a dozen have been brought into cultivation.

IMPORTANCE OF INTRODUCING NEW GRASSES.

The importance of introducing new grasses, and of efforts to improve those already cultivated, can not be overestimated. We are by

no means certain that we are now cultivating the best kinds, or that these have been brought to their highest degree of perfection. New and peculiar varieties may be produced, adapted to special purposes, *combining the excellence of two or more species*, and thus adding largely to the value of our pastures and meadows. This improvement would also extend to the stock feeding upon the improved grasses, yielding a better quality of beef, butter, etc. With a more intelligent selection of hay plants for cultivation, the average production per acre, which is now 1.14 tons, might be raised to 1½ or 2 tons. If this latter amount could have been attained in 1894, it would have added 41,396,483 tons to the total hay crop of that year.

FORAGE PLANTS IN THE GARDEN.

A grass garden, in the broad, agricultural sense, of course, includes the so-called "artificial" grasses, the clovers, and other fodder plants, which may be cultivated for hay or pasturage. These are grown in the garden for the same purpose as the true grasses, namely, to exhibit the several and varied kinds, to test new or untried varieties, and to raise material of the more promising sorts for further and wider propagation. From time to time seedsmen advertise new varieties of fodder plants for which they sometimes claim astonishing merits of productiveness, or resistance to this contingent of dryness, or that of poor soil, or extremes of heat and cold, and it should be the function of these gardens, if conducted under State or national authority, to investigate these plants, to cultivate them in the garden, and then to inform the public as to their real merits. The farmer who might be led by glowing advertisements to spend his hard-earned savings for seeds of worthless plants has in such gardens a real and vital interest, for they are designed to, and will, protect him from unscrupulous dealers, or prevent foolish expenditures, leading only to financial loss and disappointment.

The grass garden is designed to afford an opportunity to carry on the various lines of work and investigations here pointed out. What work has more practical significance, or can be more important?

FORAGE CONDITIONS OF THE PRAIRIE REGION.

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AREA AND GENERAL CONSIDERATIONS.

There are in the valley of the Mississippi and its tributaries more than 500,000,000 acres of prairies, covered with the characteristic black alluvial soil. It is the largest compact body of agricultural lands in all the world. There are other similar regions of less extent in Argentina and European Russia in which the black loam lies just as deep and the broad acres are just as fertile, but there is no like extent of territory where the climatic conditions are so favorable to the development of agriculture in its most intensive and profitable state. All plains regions, because of their physical configuration, are subject to great and sudden changes of temperature, there being nothing to break the force or alter the direction of the powerful winds that continually sweep over them. But lying, as our Western prairies do, entirely within the temperate zone, the conditions of existence are better there than in any other similar region. The prairies are neither devastated by the terribly destructive *pampero* of subtropical Argentina, nor are they subject to the intense winter cold of subarctic Russia. They are so situated that all the conditions governing the growth, development, and perfection of cereal crops are of the best, in the same ratio that the social status and position of the American farmer is better than that of any other people.

The area of the black soils and plains of European Russia is 665,000 square miles, of which 250,000,000 acres, or nearly 60 per cent, may be designated as farm lands, suitable for some form of agriculture. Argentina possesses 740,000 square miles of pampas and plains, of which less than 200,000,000 acres are suitable for farming. The arable prairies of the 13 States and Territories, from North Dakota and Ohio to Texas, amount to about one-half of their total area, or fully 300,000,000 acres.

There are large bodies of alluvial soils in China, but their products have never entered into competition with our corn and wheat and cattle in the markets of the world, and probably never will. There are smaller belts of wheat and corn lands in India and Australia and South Africa, but the chief sources of competition, and those we have most to fear, are Russia and Argentina. With the opening up of

great bodies of new lands in the countries named, suited to the cultivation of corn, wheat, flax, tobacco, and cotton, the world's supply of agricultural products is increasing more rapidly than the demand. There has been a steady decline in the prices of farm products, and the margins of profit are continually becoming less. Every year emphasizes the need of a more diversified system of agriculture.

The farmer, to succeed, must not depend upon one crop, be it corn, wheat, or cotton. Extensive farming can not be practiced except on cheap, new lands, and it is the corn and wheat harvested from such lands that govern the price. The farmer in Kansas whose land is worth $40 per acre, and who pays a high price for labor, can not compete at growing corn and wheat with the Argentinian or Russian farmer whose land is worth $10 per acre, and who pays low wages for labor, so long as both send their grain to the same market. The margin of profit for the latter is greater, and he can afford to sell his grain for less than it costs the American farmer to produce it. It is the general belief that this competition will increase rather than diminish during the next quarter century. The remedy for this condition of affairs is to be sought in a more diversified system of agriculture, in the production upon each farm of a greater variety of things to sell, and by raising products of a better quality.

FIG. 70.—Buffalo grass (*Buchloe dactyloides*).

The amount of raw prairie land suitable for farming is rapidly becoming less, and before we have converted all of it into plowed land let us consider whether such a course is most advisable. There is no longer any large tract of unbroken prairie east of the Mississippi River. The prairies are now confined to the Dakotas, southern Minnesota, Iowa, Nebraska, Kansas, Oklahoma, Indian Territory, and Texas. In all these States the richest of the prairies have been converted into wheat, corn, or cotton fields, to add by their products to the congested condition of the world's markets.

For many years our agricultural prophets have been predicting just the state of affairs that has come to pass, and have been preaching

less corn, wheat, and cotton, and more grass and cattle. It is human nature to wish to become rich as quickly as possible, and most farmers have chosen the corn and wheat route as being the shortest crosscut to wealth by giving the largest returns for the least labor. The advantages of raising enough grass to feed a sufficient number of cattle to eat the corn on the farm have been lost sight of. It has been demonstrated both by experiment and practice that the farmer who sells beef, pork, and mutton that he has produced from corn and grass raised and fed on the farm makes more money per acre of his land and per dollar of his capital than the one who grows only wheat or corn or cotton. It is not necessary to entirely discontinue raising these crops, but if we are to produce a surplus to be sold in foreign markets, it is best to export that surplus in the most condensed and marketable form, as meat and animal products, that people want to buy, rather than in the original crude and bulky state, that people do not want to buy.

The forage question in the prairie States practically resolves itself into—*Shall we raise more cattle upon the farm? or, opposed to that, Shall we plant more corn?* A proper discussion of the subject of the forage conditions of the prairie States can not be undertaken without a thorough understanding of the necessity that has arisen for the more extensive use of forage crops. The entire cattle and sheep industry is absolutely dependent upon the question of forage. The United States sells abroad about 350,000 head of fat cattle each year. The market is always open for a quality of beef better suited to the buyer's taste. An overstocking of the markets will never occur if we send only products of the best quality; and the best quality of beef, mutton, milk, butter, and cheese can be produced only by the proper use of the best forage crops. Viewed from this standpoint, the future for the cultivation of forage crops is very bright all through the prairie States.

The prairies in their wild state were covered with the richest possible grass flora. There was no similar region that had so many useful species and so few poisonous or injurious ones. Almost any square mile of the whole extent of territory could furnish in one season 50 kinds of grasses and native forage plants, grasses that would make from one and a half to two tons of hay per acre as rich as that from an Old World meadow. It was a magnificent legacy to the rancher and the farmer. To the one it promised food for a million cattle; to the other it proved the golden possibilities of a soil that would bring forth bountiful harvests. But within the last thirty years all this has changed. We can no longer point to our broad prairies and say that the natural forage conditions here are the best in the world. Hardly an acre remains anywhere east of the ninety-seventh meridian that will still yield its ton and a half of prairie hay. There is hardly a square mile of prairie sod that will produce 30 kinds of native wild grasses and clovers per annum.

The nutritious mesquite and buffalo grasses (fig. 70) have been driven to occupy the waste lands along roadsides and railway tracks, where they are rapidly being choked out and exterminated by weeds. Many of these wild grasses are superior in nutritious qualities, as shown by chemical analyses and digestive tests, to the cultivated or "tame" grasses of which we buy seeds from foreign countries. Many of the native prairie species have seeds that are just as easy to harvest as those of timothy, rye grass, tall oat grass, and dozens of other tame species, but they have never been collected in sufficient quantities to place upon the market or to make long-continued tests as to their adaptability to cultivation. These wild species should be taken care of until we are sure that we have not something better. They are acclimated. They will endure drought and freezing and flooding and all the other climatic excesses to which they have been subject for centuries. They are the best grasses for the region, because they are the natives of the region. It behooves us to plant seeds of these prairie species before some foreign seedsman sells them to us for their weight in gold, with the promise that they will yield a hundred tons of fodder to the acre.

East of the ninety-seventh meridian the yearly precipation averages from 30 to 40 inches. This belt has been termed the "humid" prairie region, having sufficient rainfall nine years in every ten to insure fair crops. Here tame grasses and clovers are uniformly successful. It is in the "arid" and "semiarid" prairie belts that there is the greatest need of thorough and long-continued experiments with the grasses and forage plants. It is in the arid prairie region that native grasses will be especially valuable in cultivation, because they will not have to be acclimated.

THE ARID PRAIRIES.

Those portions of Kansas and Nebraska that lie west of the one hundredth meridian, and a considerable range of territory extending as far east as the ninety-seventh, constituting what is known as the arid and semiarid belts, receive only from 15 to 22 inches of rain per year. In the most favorable seasons these lands, which are exceedingly fertile, produce large crops of corn, wheat, and other cereals; but such favorable seasons are uncommon, the average for any series of years being only about two out of five, so that farming, in so far as it relates to the growing of cereals, yields only a bare living.

The amount of water that the arid prairies receive would be sufficient if it were distributed uniformly through the winter and the growing season, or if it came in drizzling showers so that it would all be absorbed; but it usually comes in sudden torrents. A small amount is caught and held by the soil, and a larger amount is carried away by the streams. The arid and semiarid lands vary from 1,500 to 3,000 feet in elevation. They were originally covered with a turf

composed of buffalo, grama, mesquite, blue stem, and wild-wheat grasses, that formed an excellent natural pasture for the immense herds of buffalo, elk, and antelope, and later for the ranch cattle. These lands can not be called agricultural. True, they have a rich soil and will yield bountiful crops under irrigation or in good seasons when the rainfall is properly distributed, but so long as these conditions are beyond control and can not be supplied the lands do not and will not compete with those of the more humid regions farther east. There may be isolated valleys all through this high prairie where the "water table" stands so near to the surface that crops can send their roots down to it, and where the under-ground water is in quantity sufficient to be used for irrigating small patches, but the bulk of the lands can not profitably be used for farming. It is a grazing and not a farming section.

The close buffalo grass or grama sod sheds water as well as a shingle roof. The surface soil may become moist to the depth of 2 or 3 or 4 feet beneath such a sod; then for a great depth the subsoil is absolutely dry down to the water table, or point at which water may be obtained in wells. This was the condition of the plains of eastern Colorado at the time the first irrigation ditches were constructed, twenty years ago, and the same condition of affairs exists to-day through the whole arid region. It is well known that after the opening up of an irrigation ditch through such soil the absorption of water is enormous, and this soaking up of water continues until the subsoil is saturated to a depth of 40 feet or more. It would take a hundred years to fill the subsoils of the arid region in this way if the water supply were available, which it is not.

FIG. 71.—Little blue stem (*Andropogon scoparius*).

If it were desired to change western Kansas and Nebraska from a grazing to a farming region, the most practicable way would be to break up every acre of the prairie sod to enable the ground to absorb

more of the annual precipitation. If this were to be done, it would take perhaps ten years to saturate the subsoil to a sufficient depth. Such a course would be neither practicable nor desirable, as there is already too much land available for growing cereals. These high arid and semiarid prairies are fine grazing lands, and will continue so for many years if they are properly treated.

NATIVE FORAGE PLANTS.

The big and bushy blue stems (*Andropogon furcatus* and *A. nutans*) are leafy perennial grasses that grow best along sloughs and bottom lands and on the moist upland soils. Twenty-five years ago they were confined mostly to the valleys, but as the country has become more thickly settled they have continued to spread over the uplands. They are now the dominant grasses of the humid prairies, contributing fully 60 per cent of the wild hay cut in the whole region. Both these grasses stand pasturing well, and both show such a preference for moist, loose soils that they will undoubtedly do well under cultivation. Hay cut from prairie meadows, where the blue stems predominate, is considered first class. Stock relish it, and eat it as well as they would the best tame hay.

Chemical analysis shows that these grasses are very nutritious.

Hay of—	Where grown.	Water.	Ash.	Fat.	Nitrogen-free extract.	Crude fiber.	Albuminoids.
Andropogon furcatus	Nebraska	14.30	6.74	1.80	50.10	22.50	4.56
	Indian Territory	14.30	3.50	2.73	49.36	26.72	3.39
	South Dakota	7.44	4.16	1.86	48.40	33.88	4.26
Andropogon nutans	Texas	14.30	7.86	1.40	43.12	30.58	2.74
	Indian Territory	14.30	4.46	2.18	51.21	24.53	3.32
	South Dakota	7.75	6.40	1.57	45.70	34.73	3.85

The above table is a compilation of various analyses that have been made of hay of these two species grown in the prairie region. These species extend from North Dakota to Texas and east and west throughout the humid and semiarid belts. They are less abundant in the arid prairies and ranges, where their place is taken by the little blue stem or bunch grass (*Andropogon scoparius*). The latter is smaller and less leafy, and the stems become so hard and woody after flowering that cattle will not touch it as long as there is anything else to eat. When young, bunch grass makes good pasturage, but it is too much like the broom sedge of the South (*A. virginicus*) to ever be of much value.

Switch grass, or false redtop (*Panicum virgatum*), extends over the whole prairie region, and grows both in the fertile valleys and on the more sterile and drier hills. It forms a considerable percentage of some hay, but ought to be cut before the stems get hard and woody. It makes a coarser hay than the blue stems. In pastures it is not of

so much value. The seeds are large and abundant, and easily gathered. It grows well under cultivation and, while we would not recommend it to be sowed alone, it will undoubtedly be valuable in mixtures with other grasses. It is a vigorous grower, and will neither winterkill in North Dakota nor succumb to drought in the arid sections of Kansas or Nebraska. The following table gives its chemical composition:

Hay of—	Where grown.	Water.	Ash.	Fat.	Nitrogen-free extract.	Crude fiber.	Albuminoids.
Panicum virgatum	Indian Territory	14.30	4.70	2.85	48.81	24.95	4.39
	Texas	14.30	6.20	1.42	42.33	31.52	4.23
	Oklahoma	14.30	3.92	2.55	49.19	27.64	2.40
	South Dakota	7.29	6.50	2.09	43.99	33.89	6.24

The various species of wild-wheat grass are the predominant hay grasses of the arid and semiarid prairies. They have, as a common characteristic, tough under-ground stems or creeping rootstocks, and form a close, tough sod. The stems are leafy and nutritious. Wheat-grass hay is eaten greedily by all kinds of stock. These grasses will stand a great deal of hard usage, and are perfectly hardy in either drought or cold. They are a very valuable component of the natural range pastures. They do as well under cultivation as in the wild state, and deserve to be taken care of. The following table gives their chemical composition:

Hay of—	Where grown.	Water.	Ash.	Fat.	Nitrogen-free extract.	Crude fiber.	Albuminoids.
Agropyrum repens	S. Dakota	7.00	6.93	1.93	41.90	33.02	9.22
Agropyrum spicatum	do	8.22	7.82	2.67	40.27	32.03	8.99
Agropyrum caninum	do	6.09	8.00	1.80	38.21	41.23	4.67
Agropyrum Richardsoni	do	5.30	7.34	1.71	40.47	39.43	5.75
Agropyrum tenerum	do	7.78	5.29	2.55	46.25	29.92	8.21

The best and most widely distributed of these species is the Western wheat grass (*Agropyrum spicatum*), which occurs from North Dakota to western Kansas and westward through the plains and Rocky Mountain region. Wherever it grows it is highly esteemed. Meadows in the sand-hill region of Nebraska, where there was hardly any other grass, have yielded 2 tons of hay per acre. Most of the hay cut in the arid region of Nebraska and the Dakotas consists of one or more of these five wild-wheat grasses. They mature earlier in the season than the blue stems, and to make the best quality of forage should be cut before the seed is ripe.

The gramas, or mesquite grasses, are valuable species. Mesquite, side-oats grass, or grama (*Bouteloua curtipendula*), is a very leafy species that forms about 10 per cent of the hay cut on the uplands

of the "humid" prairie region. It is, like the big and bushy blue stems, spreading rapidly. It does not make a close turf, like the other gramas, but grows in mixtures with the leafy prairie species. Side-oats grass stands pasturing well, and is not injured by continued cuttings. The other two species, white grama (*B. oligostachya*) and blue grama (*B. hirsuta*), while they do occur scattered through the prairie flora of the eastern prairie region, do not figure as hay grasses. They are most plentiful on the ranges, where, with buffalo grass, they make up about 50 per cent of the total wild forage. They are low, close-growing species, that make dense mats of turf, often many yards in diameter, to the exclusion of all other species. They will live through a vast amount of trampling, close grazing, drying, and hard usage, and their fine leaves and stems make the best kind of summer and winter pasture. They will not be as valuable under cultivation as the side-oats grama, except in a mixture for pastures. Like the true buffalo grass, these grasses can not live through the changed conditions that have been brought about in the agricultural sections, and are rapidly disappearing. On the ranges, however, they are still quite plentiful. The praises of buffalo grass (*Buchloe dactyloides*) have long been sung, and there is not a farmer or a rancher in all the prairie region that does not know the value of this species. It has been tried in cultivation in the Eastern States, and promises to become one of the very best pasture grasses. It makes a remarkable growth when transferred to the heavy clay soils of the East, where the rainfall is much greater than in its native habitat. It can be established in a meadow by scattering the roots and fragments of turf in shallow furrows, in the same way that Bermuda grass is started in the South. We know that the value of this grass in permanent

FIG. 72.—Side-oats grama (*Bouteloua curtipendula*).

prairie pastures is great, and that it will survive drought and intense cold, but, like most other native species, it can be exterminated by overstocking the pastures in which it grows. In the sandy Platte, Republican, and Arkansas valleys it spreads rapidly on irrigated fields, and will drive out such strong-rooted grasses as Hungarian brome and timothy, which are not natives of that region. The habit of growth of buffalo grass is such that it can live through long droughts, but it must not be supposed on that account that it will thrive under such unfavorable conditions. A cactus plant will live a year without water in the Arizona or Chihuahua desert, but if it is transplanted to some garden where it can be watered, it will grow ten times as rapidly as before. It is the same with the buffalo grass. It only needs to be transplanted to places where it can get more water, and it will hold the ground against the encroachments of the taller-growing species. It is one of the earliest grasses to appear in spring, and furnishes fine forage through the winters. The following table gives chemical analyses by Shepard of gramas and buffalo grass collected in South Dakota:

Hay of—	Water.	Ash.	Fat.	Nitrogen-free extract.	Crude fiber.	Albuminoids.
Buchloe dactyloides	7.24	10.38	2.28	48.25	26.66	5.19
Bouteloua curtipendula	7.05	9.07	1.72	41.87	35.10	5.19
Bouteloua oligostachya	6.69	8.11	2.03	45.37	29.30	8.50
Bouteloua hirsuta	7.28	9.40	2.36	45.06	30.45	5.45

There are two species of prairie June grass, or early bunch grass (*Eatonia obtusata* and *Kœleria cristata*), widely distributed through the whole prairie region. They are early grasses, ripening their seed during June and July. The prairie June grass (*Kœleria*) is a particularly promising species on account of its abundance of long root leaves, which continue green through the season after the seed has ripened. In eastern Nebraska these species together furnish 10 or 15 per cent of the prairie hay, especially of that cut on the moist upland prairies. They stand pasturing well, and, like the buffalo grass, mature early. Both do well under cultivation. They are best propagated by seed, which ripens in large quantities each year and is not hard to collect.

Analyses of these grasses, made by Shepard at the South Dakota station in 1894, show their chemical composition to be as follows:

Hay of—	Water.	Ash.	Fat.	Nitrogen-free extract.	Crude fiber.	Albuminoids.
Kœleria cristata	7.89	9.95	4.33	43.01	27.59	7.23
Eatonia obtusata	7.64	12.72	2.38	40.03	30.22	7.01

There are many other nutritious and hardy species that are distributed throughout the prairie region, contributing value to the native grass flora. Some of these are limited in their distribution to particular soils and are there the dominant species of the pastures and meadows. There are grasses in North Dakota that do not grow in Kansas, and grasses considered valuable in one section or upon one soil that would be worthless if transplanted to other soils. But the species just enumerated are the most important ones of the prairie region as a whole. They are the grasses which furnish 90 per cent of the wild hay and pasture. They are also those best adapted for conservation and cultivation.

Another hay and pasture grass is cord grass (*Spartina cynosuroides*), that grows along wet river bottoms and sloughs, and, with a number of sedges and rushes, makes a fair quality of coarse hay. Mixed with it on the bottom lands are usually found the various kinds of wild-rye grass (*Elymus* sp.). All of these are better for hay than for pasture. On the dry hills of the James and Missouri valleys in Dakota, and in the sandhills of Nebraska and Kansas, blue stem (*Calamagrostis canadensis*), sand grass (*C. confinis* and *Calamovilfa longifolia*), turkey-foot (*Andropogon hallii*), and the needle grasses (*Aristida* and *Stipa*), all of them strong-growing species and rather coarse and woody compared with the blue stems, furnish excellent pasturage and, when cut in time, a fair quality of hay. The alkaline soils have their salt grass (*Distichlis*) and wild barley (*Hordeum*), and a scant covering of lowly annuals. The false redtops (*Eragrostis pectinacea* and *Triodia purpurea*) are common autumnal grasses on the upland prairies of eastern Nebraska and Kansas. There are also species of native clovers (*Petalostemon*), vetches (*Vicia* and *Lathyrus*), shoe strings (*Psoralea*, *Dalea*, and *Amorpha*), rattle pods (*Astragalus*), and beggar-weeds (*Desmodium*), widely distributed through the prairie States that add to the value of the wild meadows. One of them, wild vetch (*Hosackia purshiana*), is very abundant in the valleys from the Blue River to the upper Missouri. It is worth as much to the stockmen on the ranges as many of the tame clovers are to the farmers of the Eastern States. This wild vetch thrives under cultivation, and ought to be planted on a larger scale.

PRAIRIE HAY.

The yield of wild hay in the prairie region is far from uniform, depending as it does upon the amount and distribution of rainfall through the growing season. Hay meadows that are cut continuously for a number of years deteriorate rapidly, both as to yield and quality of hay. The latter depends upon the relative amount of weeds that the hay contains.

Wild meadows are not given the same treatment as tame meadows. They are neither reseeded by the farmer nor allowed to reseed

themselves. The natural result is that the vitality of the grasses is diminished and they are unable to hold their own against the weedy perennials that are so abundant in all prairies. These weeds increase so rapidly that they soon gain the upper hand and become more numerous than the grasses, and the meadow loses its value as hay land. Good hay land is worth anywhere in the West $10 to $20 per acre more than any other class of raw prairie. An average yield from such meadow land is a ton and a half to the acre. In exceptional seasons it often amounts to 2 or 2½ tons, while in years of drought it falls to a ton or less. The price of good prairie hay varies from $2.50 to $10 per ton, baled, at the railroad, according as the visible supply of hay varies throughout the United States.

FIG. 73.—Big blue stem (*Andropogon furcatus*).

With such yearly yields, and at such prices, it will pay to improve the prairie meadows, so that the product shall not decrease in amount or deteriorate in quality. The wild hay grasses should be permitted to reseed themselves, if not one year in three, at least one in four or five. Cutting the grass early in the season would help to keep down the weeds. It is a matter of observation that the species of weeds which increase most rapidly in the hay fields are those that blossom and ripen their seeds before the hay is ready to cut. Their increase can be checked only by cutting them while they are in flower, and thus preventing the seed from ripening. The intermingled mass of weeds and grass along the sloughs and draws or on the ground where old stacks have stood should be mowed and burned, or at least raked off the field. Otherwise these weed patches will grow in size from year to year and reduce the yield of hay.

The hay crop of the West is a money crop that annually brings in hundreds of thousands of dollars. As the acreage of raw prairie

decreases the value of prairie hay will continue to increase, so that to properly care for the hay meadows and prolong their period of usefulness will become a paying investment.

The prairies in their natural state were covered with an exceedingly rich grass flora. They were superb grazing grounds, clothed from early spring to late autumn with a succession of the most nutritious grasses, and in winter with standing hay as good as or better than tame hay. Forage was plentiful and cheap—to be had for the cost of gathering it. The early settler saw no need of cultivating grasses and clovers, for was there not at his very door better pasture and better hay land than he could get with his timothy and clover in many years at much labor and expense? Those who are interested in better forage conditions for the prairie States have continually to face this argument, even in sections where the best native grasses have been all but exterminated. Farmers in the West say that prairie hay is better and cheaper than tame hay, and if cattle will live through a winter on what they can pick up from the prairies, what is the use of planting all these forage crops? Such has undoubtedly been the state of affairs over the entire region, but it can not last much longer, and if we want to be forehanded and prevent the great losses of live stock that occur every time there is a bad season, we must take time by the forelock. To depend upon the natural hay to carry a herd through the winter, is trusting too much to chance. If there is a mild winter, without heavy snows, the cattle sometimes make a considerable gain in weight by the time grass starts in the spring.

The occurrence of such a winter or series of winters always causes a boom in the cattle industry. But if the winter is severe, with heavy snows that do not drift but lie evenly over the ground, cattle can not pick up enough of this natural hay to more than sustain life, and the herd comes out poorer in spring by a good many tons' weight of fat and flesh. To make good beef and raise cattle at a profit it is necessary to keep the steer growing continuously from birth until it is ready for slaughter. The more rapid the growth the sooner cattle can be turned off; and the quality of the beef will be better, commanding higher prices. The only natural solution of this problem is to raise grasses and clovers so as to be able to supplement the scanty feed in periods of scarcity.

Thus we see that the problem of improved forage conditions in the prairie region, whether looked at from the standpoint of the farmer or from that of the stockman, centers upon the one question, Shall we plant grasses? To this there can be but the one answer: As the cultivation of grasses and forage plants is at the foundation of agriculture, if we are to improve the quality of our farming lands and increase their capacity for production, we must devote more acres to grass. It is absolutely necessary to impress this fact upon the intelligent and progressive farmer.

TAME GRASSES AND CLOVERS.

The statement is often made that the tame grasses and clovers will not do as well on the rich prairie loam as on the heavier soils of the Eastern United States. We hear farmers say that the reason they do not sow grasses is because they will *not* grow. There is no soil better adapted to grass culture than one that has been made by grass. But, as in everything else, one must know how to treat his grass crop to make it succeed. The crops obtained from new land for the first dozen years are so abundant and the yields are so great, compared with the amount of labor that the farmer must bestow upon his field to obtain them, that he often forgets that there may still be some things that require care to produce. Tame grasses will grow in any of the prairie States, but they must be given as much care and cultivation in Nebraska as they receive in New York.

SOILING CROPS.

The dairying industry is growing very rapidly in the prairie States, where hundreds of creameries have been started within the last six years. The question of summer forage is therefore becoming an important one, for there is usually a period of from four to eight weeks in late summer when pasturage is scanty. A succession of forage crops is needed, especially such as will furnish green food in early spring and during the August and September drought and in late autumn, when pastures are bare.

Very little has been done in this line, so that in recommending such fodder crops we can only draw upon our knowledge of what ought to do well under the known conditions of the region. What is needed is some plant or plants that will send roots down deep in early summer, something that will withstand the heat and drying winds of August and September, when no water is to be had anywhere except in the subsoil. For such forage plants we must look among the deep-feeding clovers and their relatives. Hairy vetch and field peas make excellent green fodder for milch cows, fed alone or with rye. These and crimson clover, sowed in early spring, would furnish an abundance of forage up to the time when green corn and millet are ready. Cowpeas and soja (or soy) beans planted alone in drills or in the corn rows, any time from the middle of May to the middle of June, will be ready to feed during August and until the first frost in September. Then, to supplement the pumpkins and root crops that ought to be grown on every dairy farm for autumn feed, there should be more vetches and crimson clover planted in the latter part of August, provided there is moisture enough in the soil to start the seed. Cowpeas do not usually ripen seed farther north than Kansas, but the seed is cheap and easily obtained, and the forage is excellent in quality and quantity. These and the soja beans are among the richest and most nutritious plants of the clover family.

To obtain the best results and utilize as much as possible of the food which they contain, these crops should be fed with some coarse fodder, such as corn, millet, or sorghum. They may be called concentrated foods when compared with the latter, because they approach in their chemical composition wheat bran, linseed and peanut meal, and cotton-seed cake, which are fed with the winter rations. All dairymen and stock feeders recognize that these two classes of forage must be combined to produce milk or meat at the lowest cost, and often the desired nitrogenous food can be produced more cheaply upon the farm in the form of some one of these clovers and beans than it can be purchased as bran or oil cake. Thus it becomes doubly important that the acreage of summer forage crops shall be increased.

FIG. 74.—White grama (*Bouteloua oligostachya*).

IMPROVEMENT OF THE RANGES.

There has been much written and said within the last ten years about the deterioration of the ranges. Cattlemen say that the grasses are not what they used to be; that the valuable perennial species are disappearing, and that their place is being taken by less nutritious annuals. This is true in a very marked degree in many sections of the grazing country.

The one great mistake in the treatment of the cattle ranges, the one which always proves most disastrous from a financial standpoint, is overstocking. It is something which must always be guarded against. The maximum number of cattle that can safely be carried on any square mile of territory is the number that the land will support during a poor season. Whenever this rule is ignored there is bound to be loss. The present shortage of cattle all through the West is due to the fact that the ranges were stocked up to the limit that they would carry during the series of exceptionally favorable grass years preceding the years of drought. Then followed a series of bad years,

when the native perennial grasses did not get rain enough to more than keep them alive. The cattle on the breeding grounds of the West and Southwest died by thousands from thirst and starvation. It may seem like throwing away money not to have all the grass eaten down, but in the long run there will be more profit if there are fewer head carried per square mile.

The most nutritious grasses are not the annuals, which live only just long enough to produce seed and then die, but the perennial ones, which store up in their stems and running rootstocks quantities of starch and gums and sugars, to be used by the plant when growth commences, at the end of the winter, or dormant, period. The perennial grasses are the ones that furnish the "natural hay" or winter forage. On those prairie pastures which are not overstocked a large percentage of all the grasses produce seed, a condition necessary if the continued existence of any species is to be maintained. But where there are too many cattle on the range, the flowering stems of the grasses are eaten off just as soon as they appear, and the grass is often "eaten into the ground." It is with these wild grasses just as it is with the tame ones. If the perennial species are not allowed to reseed themselves, if every leaf is eaten off just as soon as it peeps from the sod, the plants can not survive. A turf grass like Kentucky blue grass will stand such treatment, but the grasses of the plains and arid prairies are not turf formers. They are for the most part "bunch grasses," and can not quickly adapt themselves to the changed conditions which require them to spread by sending out creeping runners beneath the sod. Their numbers have always been kept up by free seeding.

Clearly, then, if the grazing quality of the ranges is to be improved, they must be so treated that the nutritious native species of grasses and forage plants can spread by means of the ripened seed. This can be accomplished by dividing the range up into separate pastures and grazing the different fields in rotation. There is a constant succession of species that ripen their seed from June until October, commencing with *Kœleria*, *Eatonia*, *Stipa*, and *Buchloe* in June and July, and ending with *Andropogon*, *Sporobolus*, and *Triodia* in October. If these grasses are killed out, their places will be taken by annuals of weedy proclivities, such as the numerous species of *Eragrostis* and *Aristida*, which are neither lasting nor nutritious; grasses that spring up with the early summer rains, ripen an abundance of seed, and die.

Another result of overstocking the ranges is the injury that comes from the trampling and packing of the soil through the cattle having to travel long distances to water. In the grazing regions of Australia, which are for the most part as dry or dryer than our ranges, the squatters (ranchmen) depend upon surface water the year round. Each separate pasture or paddock has its artificial pond or "tank,"

constructed where it will catch the surface flow in the wet season. Such artificial ponds scattered over the ranges would obviate the trouble that comes from cattle having to travel long distances for water. It would be well if this system were more widely adopted in our own country.

GRASSES AND CATTLE.

The success or failure of the cattle industry all through the prairie States depends upon the question of a sufficient supply of grasses and forage plants. In those sections of the country in which land is in the highest state of cultivation and the soiling method of feeding cattle is employed, three acres of ground will support five head of cattle per annum. This is at the rate of 1,066 cattle to the square mile.

If the 300,000,000 acres of arable land in the Mississippi Valley were to be devoted to such an intensive system of agriculture, and the productiveness of the land were equal throughout all the prairie States, more cattle could be raised each year than are consumed in the whole world. This grand total will give an idea of the possibilities of the land if the best crops are raised and the best agricultural methods are employed.

Such an enormous production of forage and stock would not be warranted. The feeding of cattle for the domestic or foreign market is no more a golden road to wealth than is the cultivation of corn or wheat or cotton. The market can be glutted even with cattle and meat products. The supply must be kept within the limits of demand. We do not recommend that every farmer shall abandon wheat, corn, and cotton to devote his whole farm to the production of grasses and forage plants and of the stock to eat them, but we do recommend that every prairie farmer shall cultivate at least ten acres of grasses and clovers.

GRASSES OF SALT MARSHES.

By F. Lamson-Scribner, B. Sc.,
Agrostologist, U. S. Department of Agriculture.

No one who has traveled along the shores of New England and the Middle States can fail to have noticed the numerous hive-shaped stacks of hay thickly scattered over the extensive marshes which border these coasts. The character of this hay and the elements of which it is composed can not fail to be of interest, for they are wholly unlike those of other regions; and the hay itself, while less valuable than that usually found in our markets, serves many a useful purpose and forms a very important item of local trade. In olden times the products of the salt marshes were not forgotten by the coast dwellers of New England in their annual acknowledgment of blessings bestowed by Providence, when thanks were returned upon the day which is now one of national observance.

AREA OF SALT AND TIDE-WATER MARSHES.

The area of the salt and tide-water marshes bordering the ocean and gulf coasts of the United States is roughly estimated at from 6,000,000 to 7,000,000 acres. A considerable portion of this, particularly along the river banks of the Southern States, is beyond the reach of salt water, and possesses a different vegetation from that which comes under the direct influence of the sea and which alone is considered here. The salt marshes proper, which are covered by diurnal tides, or at least receive the storm and spring tides, are sufficiently extensive to receive special notice. The exact area of this land has never been definitely determined, except in a few States. In eleven of the States bordering the Atlantic there are approximately 2,459 square miles, or more than a million and a half acres. The quality of this land varies considerably, and so do the amount and value of the hay it produces. The plants composing the herbage, however, differ but little botanically.

Except along the shores of the New England and Middle States, this land has received comparatively little attention and been only occasionally utilized. In Connecticut, unimproved marsh is valued at from $5 to $20 per acre. Diked marsh is much more valuable, as it often exceeds in productiveness the adjoining uplands. The

marshes along the Gulf coast are very extensive, but their hay product is deemed of little or no value. Those along the shores of Texas, however, afford in many places extensive and highly prized areas for the winter grazing of cattle. On the Pacific coast the marshes are insignificant in extent, except in the north, along parts of Oregon and Washington, in the region of Puget Sound. Except when diked, practically no care is given to the marshes beyond keeping open the ditches which serve to drain off the tide water. They are fertilized entirely by the deposits of the tides, or, if located near the mouths of rivers, by such fertilizing elements as may be brought down by the streams in season of floods and deposited upon them.

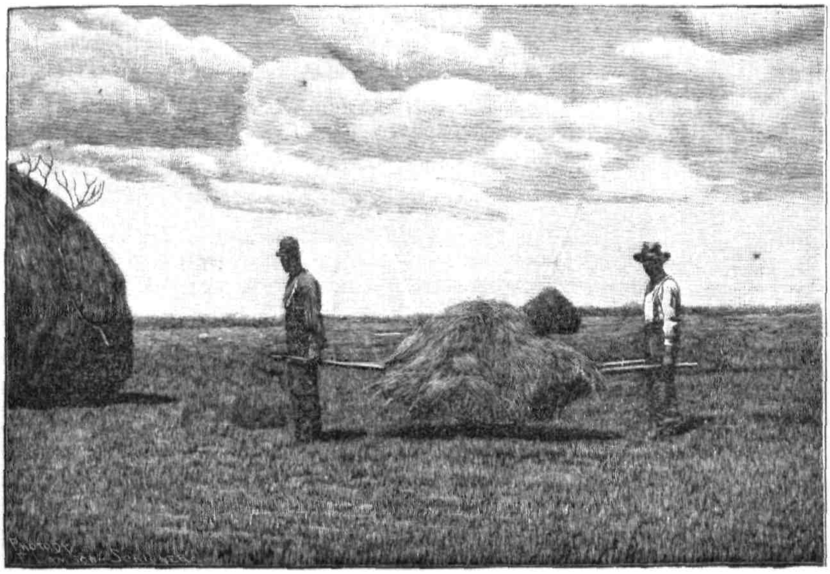

FIG. 75.—Carrying salt hay to the stack.

HAY PRODUCT AND METHOD OF HARVESTING.

The hay product of the marshes varies from half a ton to a ton or more per acre, and is harvested at any time from June to December, little attention being paid to the time of blooming of the grasses of which it is composed. When the marshes are firm enough to allow the use of machinery, the grass is cut with a mower, but in many cases this is impracticable and the cutting is done by hand. Occasionally it is necessary to take advantage of very low tides to carry on the operation of harvesting. After being cut the hay is raked, and if it can not be dried upon the marsh it is carried to the adjoining uplands, and there spread out to cure. More frequently it is stacked upon the marsh and hauled away during the winter season when the lands are frozen. The hay is taken to the stacks in various ways. One method, observed on the coast of Maine, is illustrated

here (figs. 75–77). These illustrations are from photographs taken on the marsh near Pine Point. The hay was cut and then raked up into small bundles; two poles were run under these bundles, and then the hay was carried to the stack and placed upon it. In this particular case the hay was cut upon shares, the harvester being allowed two stacks out of three for doing the work.

This hay, the value of which was given at $5 per ton, was designed in part to be used for fodder and litter, and in part to be sold in Portland for packing glassware and crockery. This latter is a very common use of salt hay in the vicinity of all the larger seaport towns, immense quantities of it being used in New York City for this purpose; the fine, and rather stiff, wiry stems of the grasses peculiar to

FIG. 76.—Making the stack.

the marshes being particularly well adapted for packing purposes, much better than the hay of the uplands. The better quality of marsh or salt hay makes very good feed for growing stock, but possesses little fattening value. Some of the grasses composing the hay impart a disagreeable flavor to the milk or butter of cows feeding upon it.

SALT GRASSES.

The grasses of the seacoast may be divided into three classes: Those growing in the sands along the shore, those upon the marshes proper, and those upon the sandy and waste lands bordering the marshes. To the first class belong beach or marram grass and a few others to some extent valuable for holding drifting sands. To the third class belong quite a variety of species of value, including switch grass (*Panicum virgatum*), slender broom sedge (*Andropogon*

scoparius), creeping fescue (*Festuca rubra*), creeping bent (*Agrostis stolonifera*), and sea spear grass (*Glyceria maritima*). The last three occasionally extend onto the marshes proper, and add much to the value of the hay product there.

The so-called salt grasses, which for the most part are limited to the marshes themselves, comprise but few species; these are, however, very characteristic, and several of them have an exceedingly wide range, one being found upon both our Atlantic and Pacific coasts, as well as along the Gulf, also along the shores of Europe. The several grasses of the marshes do not usually grow intermixed, as do the varieties which occur upon our meadows and uplands, but each species occupies by itself definite areas of greater or less extent.

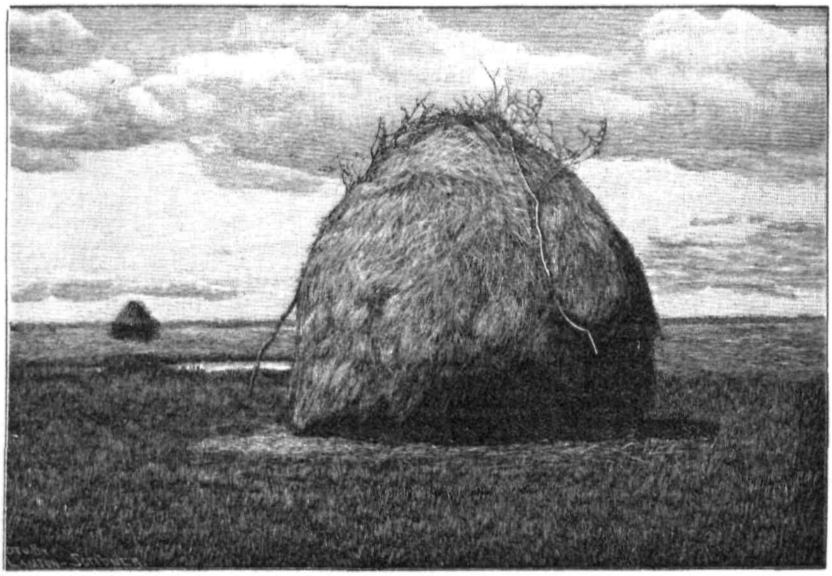

FIG. 77.—Completed stack.

The most characteristic grasses of the marshes are the Spartinas. (see fig. 78). The most common and most conspicuous of these is what is known as sedge, creek sedge, or thatch (*Spartina stricta* var. *glabra*). Where this grass grows there is usually a daily flow of tide. Along the ditches and creeks this variety grows to the height of 6 or 8 feet, and its yield in bulk is often very great. It has a narrow, spike-like head, and many long and widely spreading shining leaves of a deep-green color. This grass remains green after the other vegetation of the marsh has been turned brown by the frosts of autumn. It is of little value for fodder, but makes excellent thatch, and is used to some extent for mulching and litter. A finer grass of the same species, called fine thatch, growing to the height of 1 or 2 feet, is found over the marshes away from the ditches, and often forms a considerable element of the salt or marsh hay. This grass has, in

addition to its smaller growth, narrower, less spreading leaves, and is of a lighter color, often having a pale, yellowish tint when seen in a mass upon the marshes.

Red salt grass, or fox grass, is another species of Spartina (*Spartina juncea*), and is one of the most valuable of this family for hay; in fact, is one of the most valuable of the true grasses found upon the marshes. It grows to the height of from 1 to 2 feet, has slender, somewhat wiry stems and leaves, with a few spreading and reddish spikes composing its inflorescence. This is strictly a salt-marsh grass, and is found along our coasts from Maine to Florida and westward to Texas. While one of the most valuable of the hay-producing species of the marshes, it is also most valuable for packing crockery, glassware, etc. Locally this grass is sometimes known as "black grass," a name which properly belongs to another species, mentioned below.

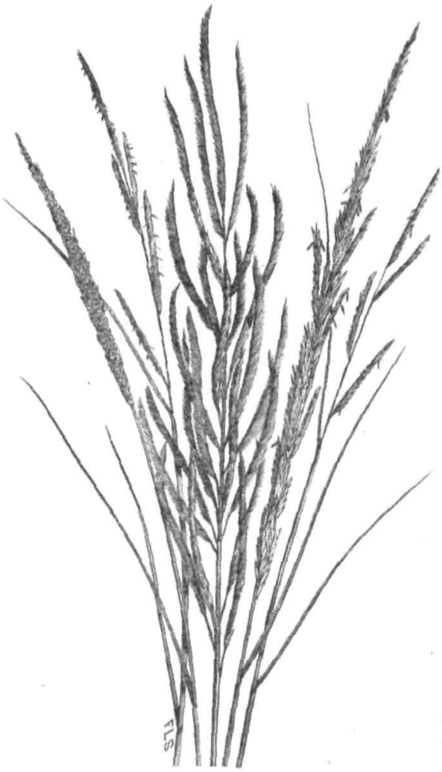

FIG. 78.—Salt-marsh grasses—the Spartinas.

Along the Gulf Coast there is another Spartina (*Spartina junciformis*), which is taller than fox grass, with longer leaves, and the spikes which form the inflorescence or head are more numerous, shorter, and very closely appressed to the main stem. The head of this is shown to the right in fig. 79, while that of fox grass is on the left.

There are two other Spartinas which are occasionally found upon the marshes, or at least upon their borders. One of these, the fresh-water cord grass (*Spartina cynosuroides*), has already been noticed under "Grasses as sand and soil binders," in the Yearbook for 1894; the other, the largest of our Spartinas (*Spartina polystachya*), is less common than the last, and is confined to the coast, ranging from Maine to Alabama. It grows to the height of from 6 to 10 feet, and has the inflorescence composed of from 20 to 60 spikes (see centerpiece in fig. 78). It forms a conspicuous feature on portions of the Hackensack marshes near Jersey City. Associated with this, upon these

marshes, is the large reed *Phragmites communis*. This grows to the height of from 8 to 10 feet, with very leafy stems and plume-like inflorescence. It is shown in the center of fig. 79. This grass is not confined to the seashore, being widely dispersed throughout the temperate regions of the world, chiefly along margins of rivers and fresh-water lakes. It has remarkably long and penetrating roots, and is especially valuable as a sand and soil binder, as has already been noted. A large grass, common also on these marshes and abundant in the tide waters of the rivers of the Middle States, notably below Philadelphia, is Indian rice (*Zizania aquatica*). This is a tall, coarse grass, with rather long, broad leaves, and the seeds are the favorite food of the reedbirds. When the seeds are ripe, these birds resort to the marshes in great numbers, making them at such times a favorite resort of sportsmen.

FIG. 79.—Salt-marsh grasses. Sea spear grass, spike grass, large reed, couch grass, browntop, creeping fescue, black-grass.

Spike grass (*Distichlis spicata*), which also has been noted as an excellent sand binder, is occasionally found upon the marshes proper, sometimes occupying areas of considerable extent, as on the marshes of Cape Cod. It is peculiar in having the male or staminate flowers and the female or pistillate flowers on distinct plants; and while the male and female plants may grow associated together, they are sometimes found separate, the male plants covering an acre or so exclusively, while in the vicinity a similar area may be found exclusively held by the female plants. This grass has very tough, extensively creeping roots, wiry stems, narrow leaves, and a compact head of flowers, and when abundant may be detected at a distance by its peculiar yellowish hue.

Upon the higher portions of the marsh, which usually escape the ordinary tides, occur several fine grasses of excellent quality. Among these are the creeping fescue, sea spear grass, creeping bent or browntop,

and black grass. The heads of these are shown to the left in fig. 79. Browntop, or creeping bent, which is common on the marshes of the New England coast and extends southward to New Jersey, is one of the best and most tender grasses for fodder which these lands produce. It is a variety of the well-known redtop, but the stems are creeping at the base and do not rise so high, and the head or panicle is less expanded. It has a decided brown tinge, whence the common name "browntop." Sea spear grass is found along the northern coasts as far south as New Jersey, and is in some places quite abundant, occasionally forming an important element in the hay. It is not so common, however, as are the grasses already mentioned. The stems are tender, the leaves comparatively soft, and the panicle has a few erect or spreading branches. By some it is classed with browntop and not recognized as distinct from it.

Creeping or red fescue which is more common on the sandy borders and waste grounds near the marshes, not infrequently occurs upon them in considerable abundance. This is particularly true of the marshes along the Jersey coast, although the grass extends northward to the shores of Maine. It is a low grass, and, when growing alone, forms an excellent turf; mixed with other species, it adds value to the hay product.

Of all the grasses of the marshes there is none more highly prized for hay than black grass (*Juncus gerardi*), which is common on all the marshes of the New England coast, extends southward to Florida, and is found on the shores of the Pacific in the Northwest. Although popularly classed with the grasses, this is not a true grass, but a rush, its botanical characters being quite distinct from those of the Gramineæ. A couple of heads of this rush are shown in fig. 79, above those of the sea spear grass. Its slender erect stems are from 1 to 2 feet high, are somewhat wiry, yet soft, and apparently palatable to stock. It contains less fiber and has a higher nutritive ratio, as shown by chemical analyses, than timothy or redtop.

There are a few other plants of the salt marshes which enter into the composition of salt or marsh hay, but as they belong to other families than grasses and are of comparatively little importance, rarely forming any appreciable amount of the product, no mention will be made of them.

The question of reclaiming salt marshes by systems of diking for the purpose of growing better hay or other farm crops has been fully discussed in publications of this Department.[1] Usually a better quality of hay can be obtained from the marshes as they exist by paying more attention to the time of harvesting. If the hay is desired for fodder, the harvesting should be done so far as possible when the most valuable grasses are in flower. If it is delayed too long past the season of bloom, much of the nutritive quality which these grasses

[1] Miscellaneous Special Report No. 7 (1884).

possessed in their season is lost. It must be remembered that the hay obtained from the salt marshes is their natural product—a free gift, as it were, of nature—no attempt being made to restore what is taken off, nor any effort to increase the growth of the more valuable sorts. Perhaps it is questionable whether it would pay to attempt to do this by collecting and scattering seeds upon the unimproved marsh or to try to destroy or collect the less desirable kinds to make place for the better varieties.

CHEMICAL COMPOSITION OF SALT-MARSH GRASSES AND HAY.

A sample of pure fox grass (*Spartina juncea*), collected on the marshes of Cape Cod, Massachusetts, about the middle of August, gave the following analysis: Moisture, 8.55 per cent; ether extract, 4; fiber, 26.88; ash, 5.41; nitrogen, 0.87; nitrogen as albuminoids, 5.44.

A sample of salt hay, composed chiefly of fox grass and spike grass, and collected near Atlantic City, N. J., in the latter part of August, gave the following composition by chemical analysis: Moisture, 7.44 per cent; ether extract, 4.02; fiber, 27.04; ash, 9.64; nitrogen, 0.77; nitrogen as albuminoids, 4.81.

A sample of salt hay, collected near Pine Point, Me., in the early part of August and made up of a variety of grasses, including black grass, fox grass, and browntop, analyzed as follows: Moisture, 8.04 per cent; ether extract, 5.44; fiber, 27.25; ash, 5.13; nitrogen, 0.94; nitrogen as albuminoids, 5.88.

The following table of analyses of the more important grasses here mentioned with those of the common meadow grasses inserted for comparison is taken from the annual report of the Connecticut Agricultural Experiment Station for 1889, page 240. The samples analyzed were gathered just before or at the time of blooming.

	Timothy and redtop.	Mixed meadow grasses.	Black grass (*Juncus gerardi*).	Red salt grass (*Spartina juncea*).	Creek sedge (*Spartina stricta*).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ash	5.5	5.5	7.9	9.3	11.7
Albuminoids	7.4	7.6	9.2	6.0	7.2
Fiber	34.4	35.6	29.0	28.6	29.4
Nitrogen-free extract	50.4	48.9	51.3	53.4	49.5
Fat	2.3	2.4	2.6	2.7	2.2
Total	100.0	100.0	100.0	100.0	100.0

The average of numerous analyses of the ash of some of these grasses shows that 5 tons of hay made from them contain as much nitrogen, phosphoric acid, and potash as is contained in a full crop of corn, including stover, from an acre of land. The average amount of salt contained in a ton of hay, according to the investigation at the Connecticut Agricultural Experiment Station, was 54 pounds.

THE RELATION OF FORESTS TO FARMS.

By B. E. Fernow,
Chief of the Division of Forestry, U. S. Department of Agriculture.

That all things in nature are related to each other and interdependent is a common saying, a fact doubted by nobody, yet often forgotten or neglected in practical life. The reason is partly indifference and partly ignorance as to the actual nature of the relationship; hence we suffer, deservedly or not.

The farmer's business, more than any other, perhaps, depends for its success upon a true estimate of and careful regard for this interrelation. He adapts his crop to the nature of the soil, the manner of its cultivation to the changes of the seasons, and altogether he shapes conditions and places them in their proper relations to each other and adapts himself to them.

Soil, moisture, and heat are the three factors which, if properly related and utilized, combine to produce his crops. In some directions he can control these factors more or less readily; in others they are withdrawn from his immediate influence, and he is seemingly helpless. He *can* maintain the fertility of the soil by manuring, by proper rotation of crops, and by deep culture; he *can* remove surplus moisture by ditching and draining; he can, by irrigation systems, bring water to his crops, and by timely cultivation prevent excessive evaporation, thereby rendering more water available to the crop; but he can not control the rainfall nor the temperature changes of the seasons. Recent attempts to control the rainfall by direct means exhibit one of the greatest follies and misconceptions of natural forces we have witnessed during this age. Nevertheless, by indirect means the farmer has it in his power to exercise much greater control over these forces than he has attempted hitherto. He can prevent or reduce the unfavorable effects of temperature changes; he can increase the available water supplies, and prevent the evil effects of excessive rainfall; he can so manage the waters which fall as to get the most benefit from them and avoid the harm which they are able to inflict.

The following three illustrations, shown as models at the Atlanta Exposition, are designed to bring graphically before the reader the evil effects of the erosive action of water, the methods by which the farmer may recuperate the lost ground, and the way the farm should look when forest, pasture, and field are properly located and treated.

FIG 80.—How the farm is destroyed.

Clearing of hilltops, excessive thinning of wooded hillsides, followed by the burning of litter, underbrush, and young growth, and the compacting of the soil by the tramping of animals, induces rapid surface drainage, and this causes erosion, gullying, and washing away of the soil.

The surface water rushing unimpeded over bare slopes and compacted soils washes away the soil, cuts gullies in fields on hillsides, and washes down silt, sand, and gravel, and spreads them over fields and meadows; thus the fertile portions of the farm are injured by the encroachment from the unfertile.

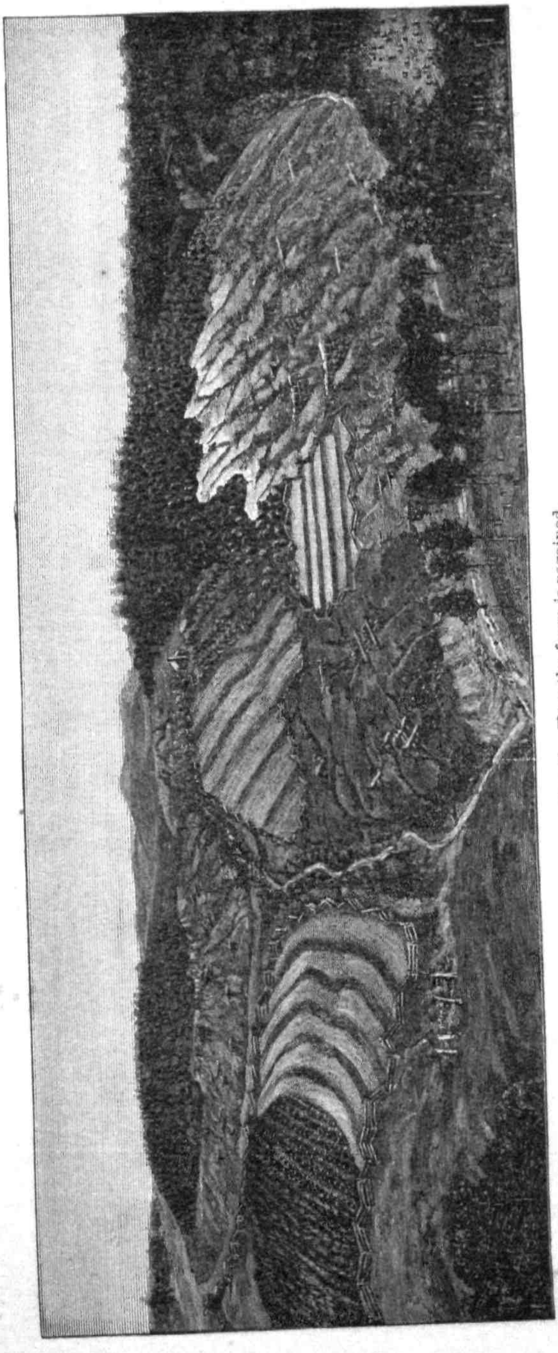

FIG. 81.—How the farm is regained.

To prevent erosion, gullying, and washing, keep hilltops and steep hillsides under forest; change surface drainage into under-ground drainage; check the rush of water by means of brush and stone dams, terracing, contour plowing, and ditching; renew organic matter in the soil by means of green manuring and mulching, and give thorough cultivation.

The rush of water must be checked by means of dense forest growth on the tops and steepest sides of hills—places where floods acquire their momentum. At such points gullies should be filled with brush and stone work, runs filled up with brush, and the soil so treated that it will permit the water to pass through it and flow off under ground.

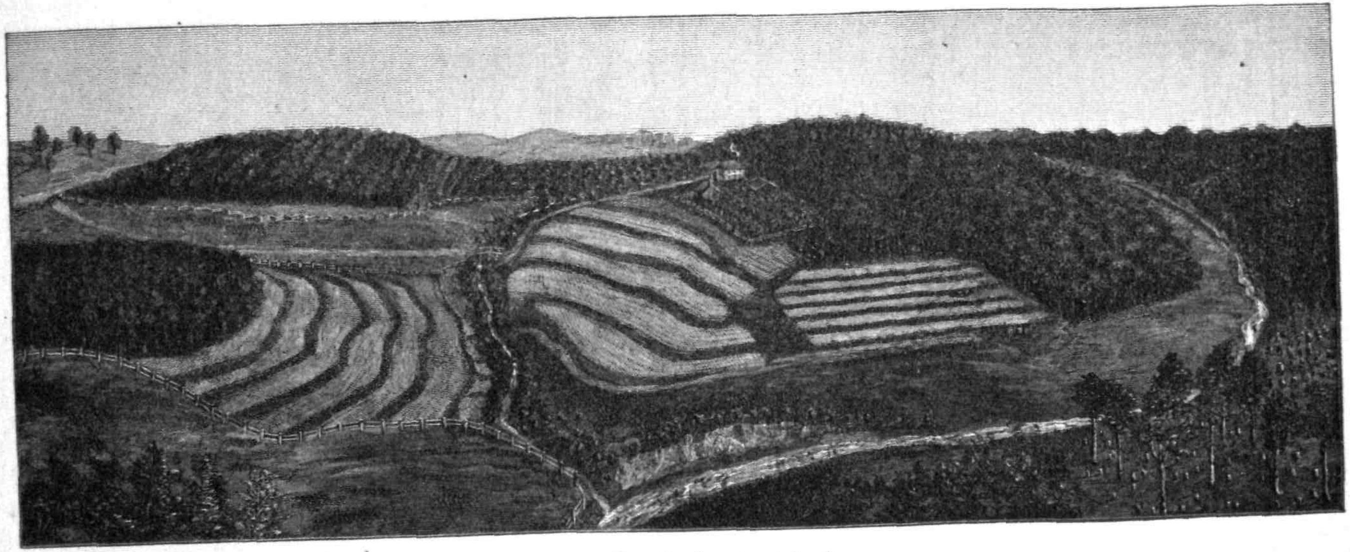

FIG. 82.—How the farm is retained.

On the ideal farm there is no waste land, every foot of ground being used for the purpose for which it is best adapted. The farm is divided into cultivated fields, pasture, and woodland, a proper proportion of ground being devoted to each; roads are made with a view to convenience and grade, and stock is fenced into the pasture—not out of the fields. Damage caused by water is to be repaired at once.

Hilltops, steep hillsides, and rocky places are kept under forest. A fringe of wood stretches along river banks, and long slopes are broken up with small groves or timber belts. Wood is cut systematically and judiciously, so that it will reproduce. Where natural reproduction fails, replanting is resorted to. The pasture is located on a gentle slope where the soil is too thin for field crops.

The regulation, proper distribution, and utilization of the rain waters in arid as well as in humid regions—water management—is to be the great problem of successful agriculture in the future.

One of the most powerful means for such water management lies in the proper distribution and maintenance of forest areas. Nay, we can say that the most successful water management is not possible without forest management.

THE FOREST WATERS THE FARM.

Whether forests increase the amount of precipitation within or near their limits is still an open question, although there are indications that under certain conditions large, dense forest areas may have such an effect. At any rate, the water transpired by the foliage is certain, in some degree, to increase the relative humidity near the forest, and thereby increase directly or indirectly the water supplies in its neighborhood. This much we can assert, also, that while extended plains and fields, heated by the sun, and hence giving rise to warm currents of air, have the tendency to prevent condensation of the passing moisture-bearing currents, forest areas, with their cooler, moister air strata, do not have such a tendency, and local showers may therefore become more frequent in their neighborhood. But, though no increase in the amount of rainfall may be secured by forest areas, the availability of whatever falls is increased for the locality by a well-kept and properly located forest growth. The foliage, twigs, and branches break the fall of the raindrops, and so does the litter of the forest floor, hence the soil under this cover is not compacted as in the open field, but kept loose and granular, so that the water can readily penetrate and percolate; the water thus reaches the ground more slowly, dripping gradually from the leaves, branches, and trunks, and allowing more time for it to sink into the soil. This percolation is also made easier by the channels along the many roots. Similarly, on account of the open structure of the soil and the slower melting of the snow under a forest cover in spring, where it lies a fortnight to a month longer than in exposed positions and melts with less waste from evaporation, the snow waters more fully penetrate the ground. Again, more snow is caught and preserved under the forest cover than on the wind-swept fields and prairies.

All these conditions operate together with the result that larger amounts of the water sink into the forest soil and to greater depths than in open fields. This moisture is conserved because of the reduced evaporation in the cool and still forest air, being protected from the two great moisture-dissipating agents, sun and wind. By these conditions alone the water supplies available in the soil are increased from 50 to 60 per cent over those available on the open field. Owing to these two causes, then—increased percolation and decreased evaporation—larger amounts of moisture become available to feed the springs

and subsoil waters, and these become finally available to the farm, if the forest is located at a higher elevation than the field. The great importance of the subsoil water especially, and the influence of forest areas upon it, has so far received too little attention and appreciation. It is the subsoil water that is capable of supplying the needed moisture in times of drought.

THE FOREST TEMPERS THE FARM.

Another method by which a forest belt becomes a conservator of moisture lies in its wind-breaking capacity, by which both velocity and temperature of winds are modified and evaporation from the fields to the leeward is reduced.

On the prairie, wind swept every day and every hour, the farmer has learned to plant a wind-break around his buildings and orchards, often only a single row of trees, and finds even that a desirable shelter, tempering both the hot winds of summer and the cold blasts of winter. The fields he usually leaves unprotected; yet a wind-break around his crops to the windward would bring him increased yield, and a timber belt would act still more effectively. Says a farmer from Illinois:

> My experience is that now in cold and stormy winters fields protected by timber belts yield fnll crops, while fields not protected yield only one-third of a crop. Twenty-five or thirty years ago we never had any wheat killed by winter frost, and every year we had a full crop of peaches, which is now very rare. At that time we had plenty of timber around our fields and orchards, now cleared away.

Not only is the temperature of the winds modified by passing over and through the shaded and cooler spaces of protecting timber belts disposed toward the windward and alternating with the fields, but their velocity is broken and moderated, and since with reduced velocity the evaporative power of the winds is very greatly reduced, so more water is left available for crops. Every foot in height of a forest growth will protect 1 rod in distance, and several belts in succession would probably greatly increase the effective distance. By preventing deep freezing of the soil the winter cold is not so much prolonged, and the frequent fogs and mists that hover near forest areas prevent many frosts. That stock will thrive better where it can find protection from the cold blasts of winter and from the heat of the sun in summer is a well-established fact.

THE FOREST PROTECTS THE FARM.

On the sandy plains, where the winds are apt to blow the sand, shifting it hither and thither, a forest belt to the windward is the only means to keep the farm protected.

In the mountain and hill country the farms are apt to suffer from heavy rains washing away the soil. Where the tops and slopes are bared of their forest cover, the litter of the forest floor burnt up, the soil trampled and compacted by cattle and by the patter of the

raindrops, the water can not penetrate the soil readily, but is carried off superficially, especially when the soil is of clay and naturally compact. As a result the waters, rushing over the surface down the hill, run together in rivulets and streams, and acquire such a force as to be able to move loose particles, and even stones; the ground becomes furrowed with gullies and runs; the fertile soil is washed away; the fields below are covered with silt; the roads are damaged; the water courses tear their banks, and later run dry because the waters that should feed them by subterranean channels have been carried away in the flood.

The forest cover on the hilltops and steep hillsides which are not fit for cultivation prevents this erosive action of the waters by the same influence by which it increases available water supplies. The important effects of a forest cover, then, are retention of larger quantities of water and carrying them off under ground and giving them up gradually, thus extending the time of their usefulness and preventing their destructive action.

In order to be thoroughly effective, the forest growth must be dense, and, especially, the forest floor must not be robbed of its accumulations of foliage, surface mulch and litter, or its underbrush by fire, nor must it be compacted by the trampling of cattle.

On the gentler slopes, which are devoted to cultivation, methods of underdraining, such as horizontal ditches partly filled with stones and covered with soil, terracing, and contour plowing, deep cultivation, sodding, and proper rotation of crops, must be employed to prevent damage from surface waters.

THE FOREST SUPPLIES THE FARM WITH USEFUL MATERIAL.

All the benefits derived from the favorable influence of forest belts upon water conditions can be had without losing any of the useful material that the forest produces. The forest grows to be cut and to be utilized; it is a crop to be harvested. It is a crop which, if properly managed, does not need to be replanted; it reproduces itself.

When once established, the ax, if properly guided by skillful hands, is the only tool necessary to cultivate it and to reproduce it. There is no necessity of planting unless the wood lot has been mismanaged.

The wood lot, then, if properly managed, is not only the guardian of the farm, but it is the savings bank from which fair interest can be annually drawn, utilizing for the purpose the poorest part of the farm. Nor does the wood lot require much attention; it is to the farm what the workbasket is to the good housewife—a means with which to improve the odds and ends of time, especially during the winter, when other farm business is at a standstill.

It may be added that the material which the farmer can secure from the wood lot, besides the other advantages recited above, is of far greater importance and value than is generally admitted.

On a well-regulated farm of 160 acres, with its 4 miles and more of fencing, and with its wood fires in range and stove, at least 25 cords of wood are required annually, besides material for repair of buildings, or altogether the annual product of probably 40 to 50 acres of well-stocked forest is needed. The product may represent, according to location, an actual stumpage value of from $1 to $3 per acre, a sure crop coming every year without regard to weather, without trouble and work, and raised on the poorest part of the farm. It is questionable whether such net results could be secured with the same steadiness from any other crop. Nor must it be overlooked that the work in harvesting this crop falls into a time when little else could be done.

Wire fences and coal fires are, no doubt, good substitutes, but they require ready cash, and often the distance of haulage makes them rather expensive. Presently, too, when the virgin woods have been still further culled of their valuable stores, the farmer who has preserved a sufficiently large and well-tended wood lot will be able to derive a comfortable money revenue from it by supplying the market with wood of various kinds and sizes. The German State forests, with their complicated administrations, which eat up 40 per cent of the gross income, yield, with prices of wood about the same as in our country, an annual net revenue of from $1 to $4 and more per acre. Why should not the farmer, who does not pay salaries to managers, overseers, and forest guards, make at least as much money out of this crop, when he is within reach of a market?

In regard to the manner in which the farmer should manage his wood lot, the Yearbook of 1894 gives a fuller account.

With varying conditions the methods would of course vary. In a general way, if he happens to have a virgin growth of mixed woods, the first care would be to improve the composition of the wood lot by cutting out the less desirable kinds, the weeds of tree growth, and the poorly grown trees which impede the development of more deserving neighbors.

The wood thus cut he will use as firewood or in any other way, and even if he could not use it at all, and had to burn it up, the operation would pay indirectly by leaving him a better crop. Then he may use the rest of the crop, gradually cutting the trees as needed, but he must take care that the openings are not made too large, so that they can readily fill out with young growth from the seed of the remaining trees, and he must also pay attention to the young aftergrowth, giving it light as needed. Thus without ever resorting to planting he may harvest the old timber and have a new crop taking its place and perpetuate the wood lot without in any way curtailing his use of the same.

TREE PLANTING IN THE WESTERN PLAINS.

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CHARACTERISTIC FEATURES OF THE PLAINS.

The plains of the West comprise a strip of country of varying width extending from North Dakota to Texas, all portions of which have the same general characteristic features. In the eastern part of this region the country is like the adjacent prairies of Minnesota, Iowa, and Missouri—rolling lands, with numerous streams bordered by woods, from which the surface rises to the open country. In the Dakotas and northern Nebraska these slopes are usually gentle, but in Kansas the surface of the land is frequently broken by outcrops of the underlying limestone. Farther south the woods increase in extent. Through the central area of the Western States (the Dakotas, Nebraska, Kansas, Oklahoma, and Texas) the tree growth is greatly reduced in extent and variety, the country is less rolling, and the altitude is higher, these conditions increasing in intensity westward until in eastern Colorado there is a vast plain rising by imperceptible degrees toward the foothills of the Rocky Mountains.

Aside from these generally prevailing conditions, the State of Nebraska is crossed east and west by a broad belt of sand hills, which make it necessary to discuss that region separately from the remaining country under consideration. A somewhat similar area, though very much smaller in extent and less pronounced in character, lies between the Arkansas and Smoky Hill rivers in Kansas.

The soil conditions over this vast area are necessarily variable. The Dakotas and Nebraska outside of the sand hills have what Western people recognize as the typical prairie soil—a deep clay loam, underlaid with a subsoil of clay of varying degrees of stiffness. Oftentimes on adjoining farms this subsoil presents widely varying characteristics; the one being almost impenetrable to moisture (the hardpan of the Northwest), and the other having a considerable admixture of sand and readily penetrated by moisture.

The surface soil is usually black in color, and, except in cases of extreme drought, can be kept in good condition, so far as moisture is concerned, by very deep plowing and frequent shallow cultivation. In Kansas and the southern country the same loamy surface soil is found, but the subsoil is frequently of a more calcareous nature, being

underlaid with limestone not far from the surface. In Colorado the surface soil is brown rather than black, and has the characteristic clay subsoil of the more northern region.

The vegetation throughout consists of grasses, composites, and legumes, with a comparatively small number of other species, almost exclusively herbaceous, except in the immediate vicinity of streams. The only common woody plants on the uplands are low-growing roses, cherry, and false indigo. The soil cover is less luxuriant, generally speaking, from east to west and from the lower to the higher latitudes, being of course largely governed by the presence of moisture in soil and atmosphere. In the moister regions the taller forms of Andropogon and Calamagrostis are the characteristic grasses, while in the drier regions the Stipas, Boutelouas, and Buchloes are dominant. The annual prairie fires have prevented as large accumulations of humus as the grass crop would otherwise have made, but the soil is nowhere lacking in an abundant supply of food elements for trees.

In all the Northern prairies there is an almost insensible passage from surface to subsoil, the change in color and grain being a very gradual one, evidently dependent on the amount of humus. It not infrequently happens that a thin stratum of coarse gravel or gravelly clay makes a line of demarcation between surface and subsoil. Throughout the plains, too, it is common to find white spots, calcareous in nature, in the clay subsoil from 3 to 10 feet below the surface. By many persons in the West these chalky deposits are wrongly considered an indication of hardpan, impenetrable to moisture. There is also a greater or less admixture of fine sand in the clay subsoil; in most cases this sand is sufficient to render the subsoil porous enough to permit the free passage of moisture. This is proven by the almost universal effect of shallow culture on deep-plowed prairie soils. The land so tilled is fresh below the dust blanket even in long periods of drought, while adjacent uncultivated land shows wide cracks on the surface of the baked earth. There are undoubtedly places, local in character and of limited extent, in which the subsoil is too stiff to permit a good growth of forest trees, but these can be regarded as exceptions rather than the rule, which is that the soils of the plains are of sufficient depth and porosity to permit the growth of trees. Whatever difficulties are met, then, must be climatic in their nature.

The mean annual rainfall gradually decreases from the eastern boundaries of Kansas and Dakota toward the mountains. The greatest rainfall occurs in the southeastern part of the region, and a gradual decrease is noticeable both northward and westward, being greater in the latter direction. On the unbroken prairies the character of the soil and vegetation has much to do with the moisture conditions. There is usually a good fall of rain during April, May, and June; then there is apt to be very little until the autumn months. During this

long interval the only protection to the soil is the herbaceous vegetation that covers it, and this is soon turned brown and sere by the excessive heat and winds. The sun, beating down on the scarcely shaded earth, tends to compact and bake it until it more nearly resembles sun-dried brick than a soil in which plants can grow. This condition varies in proportion to the amount of sand in the soil, and as the greater part of the plains is covered with a clay loam, they dry out badly and have become very compact during the centuries that they have been exposed to existing conditions. When rains fall, the water is not absorbed by such soils to as great a degree as in the prairie loams of Iowa and Missouri. It penetrates a few inches, only to be soon evaporated. Under cultivation, however, a decided change in the action of Western soils is noticeable. This was impressed upon the writer during a visit to the Kansas State forest station at Ogallah (99° 46′ W., 39° N.), in October, 1894. In walking from the railroad station to the forest plats, a distance of a mile, it was observed that the ground was cracked by the excessive drought, and it could scarcely have been harder; but in the cultivated soil of the nurseries and tree plats fresh soil was found a few inches below the surface.

The great lesson to be learned from these general observations is that deep plowing and frequent cultivation of the soil until it is shaded by the tree growth is one of the requisites for successful forest planting in these regions.

OBJECTS OF TREE PLANTING.

Without entering into a discussion of the causes of the failure which, in the majority of cases, has attended the efforts of tree planters in the States west of the Missouri River, it is intended to give practical suggestions on methods of planting and culture, with information regarding varieties of trees and the aftertreatment of cultivated woodlands.

The region under consideration is so vast in extent that it will be impossible, in a limited space, to give specific directions for planting or care under all the varying conditions of soil, altitude, moisture, wind, and the many minor items constituting what is known to the forester as locality.

Being intended primarily for farmers, the subject is treated from the standpoint of the agriculturist rather than that of the forester. The farmer, devoting comparatively small areas to the cultivation of trees, can regard the individual tree as his unit; the forester, having to do with thousands of acres, must look to the aggregate growth. Nevertheless, if the farmer would have timber from his grove that will best meet his varied needs, he must follow the same principles of selection, planting, and aftertreatment that govern the operations of the forester in his larger field.

In the Western States forest-tree planters have two special objects

in view—protection from winds and a supply of wood. Incidentally the plantations may be made to save much moisture to the tillable area of the farm; they also furnish a most important means of relieving the otherwise monotonous landscape, making the country more attractive. The great benefit derived from grove planting in the West, outweighing all other considerations, is protection from wind. Hence the groves should be so placed as to afford the most complete shelter to the farm buildings, feeding lots, garden, and orchard.

A careful examination of a large portion of the region under discussion emphasizes a belief, founded on several years' experience in tree culture in South Dakota, that over the greater part of the vast area trees can be successfully grown without irrigation. The degree of success will be greatest on the eastern borders of the plains, and will decrease westward, following the general reduction in the moisture supply of soil and atmosphere. So, also, trees will be found to grow best on the lower lands near the streams, but as the country is settled and the land is cultivated the line of successful tree growth will ascend to the higher altitudes in every part of the plain region, and ultimately the entire area can be afforested.

AVAILABILITY OF SPECIES.

The work of tree planting on the plains heretofore has been largely tentative. In the beginning there was no experience that could be used as a basis in the West, because deductions from plantings made under other climatic conditions proved almost valueless. For the first time in the history of the world, a people attempted to transform, almost in a decade, a land that had long been considered an uninhabitable desert. The paramount condition that led to a choice of varieties of trees for planting was availability. There was no question on the part of the settler of the necessity for wind-breaks. The need was so urgent that he sought the quickest solution of it and took from the sparse woodlands of the nearest streams the species that seemed to grow most rapidly. Hence throughout the West the cottonwood is the most generally planted tree, and it has served a purpose which probably no other species could have so well filled. It has made a protecting wind-break around thousands of homesteads. Next to the cottonwood the willow, box elder, and maple have been most extensively planted, these being the most rapid growing, during youth, of the native species. Throughout the West, however, hundreds of farmers have secured seed of more valuable species and have attempted their cultivation, with varying degrees of success. Throughout the eastern parts of Kansas and Nebraska thrifty groves of black walnut and green ash can be found, and there are many plantings that contain a variety of hard woods, including, in addition to those already named, the black and honey locusts, elm, cherry, and catalpa.

To a much more limited extent pines and spruces have been planted, but a lack of knowledge regarding their needs has resulted at best in only a moderate degree of success.

In these pioneer plantings, as in the wild state, trees have grown best nearest the eastern border of the plains, the artificial groves decreasing in number and in size to the westward.

The species most easily secured, because native along streams in the plains, are cottonwood, box elder, green ash, silver and red maple, willow, and hackberry. Of these the cottonwood and willow may be regarded as the most available, because they grow readily from cuttings, as well as from seeds. The silver and red maples are both of common occurrence in Kansas, but northward the red maple becomes scarcer, and is not found in the Dakotas. The maples have a less general distribution, but they grow so readily and strongly from the seed that they have been largely planted. The ash and elm, being slower growers, have not commended themselves to Western planters as their merits deserve, but are now being more extensively planted.

In the eastern plain region, especially southward, several species of oak are native, the most useful being the bur or mossy cup (*Quercus macrocarpa*), also the black wild cherry, honey locust, sugar maple (rare), red elm, sycamore, walnut, several hickories, red cedar, basswood, and buckeye. It is thus seen that a goodly number of tree species are indigenous, and seeds of all of them can be obtained in greater or less quantity without much difficulty, the most widely distributed being those first named.

It may happen, however, through the instrumentality of the nurseryman and seedman, that species not native are more available than indigenous trees. The hardy catalpa is particularly available for the southeast plain region, because the seed is cheap and the tree can be grown with ease. For the same reasons the black locust is specially adapted to Kansas, southern Nebraska, and Colorado. Among conifers the Scotch and Austrian pines, red cedar, and white spruce are yearly becoming cheaper, and hence more available to the Western planter.

In addition to these larger trees, smaller woody growths, such as wild plum, choke cherry, and sand cherry, can be secured over the greater part of the West, and may fill an important purpose in the groves.

ADAPTABILITY OF SPECIES.

The adaptability of a species is its power to adjust itself to the conditions in which it is placed. A great many failures have been made in tree growing by mistaking availability for adaptability. It does not follow because the cottonwood is growing along the Arkansas, Republican, Platte, and Niobrara rivers all the way across the plains that it will succeed equally well on the intervening highlands. It

seems able to stand almost any degree of atmospheric dryness, provided it has a plentiful supply of moisture at the root. This might appear at first thought to be equally true of all arborescent species, but the fact that so few varieties of trees are found between the one hundredth and one hundred and fifth meridians indicates the contrary. The Arkansas is a broad river throughout the driest seasons, but in western Kansas and eastern Colorado almost the only species that grows on its banks is the cottonwood. This tree is much shorter lived on high land, especially where there is a stiff subsoil, and does not live as long when planted closely as when used for street planting—a single row with wide intervening spaces; even where it grows naturally, along rivers, it soon dies out.

The black walnut has been more extensively planted than any of the slow-growing trees, with the possible exception of green ash, and here again no attention has been paid to adaptability. The black walnut succeeds best in the deep, fresh soils of bottom and second-bench lands, and in such localities there are many successful young groves in Kansas and Nebraska; on the drier highlands, however, it is much slower in growth and often fails entirely.

The silver maple has been planted extensively throughout South Dakota, where it almost invariably kills back during its early years, resulting in a coppice form that makes an acceptable soil cover but a poor tree.

The box elder succeeds much better in the Dakotas than in Kansas, where it dies in high ground after a few years, and as a nurse tree is never as satisfactory as it is farther north. On the other hand, the Russian mulberry attains a good post size in the valley of the Arkansas—a thing incredible to those who have only seen the species as grown farther north, where it becomes a spreading shrub.

The hardy catalpa (*Catalpa speciosa*) is one of the most rapid-growing trees in the southeastern part of the plains, and thrives as far north as Omaha, Nebr., but it kills back in central Nebraska, even at the south line of the State, and will not grow at all in South Dakota. The black locust flourishes over a much greater western range, growing well under irrigation at Denver, Colo., and in the dry plains of western Kansas, but it is not successful north of the Nebraska sand hills.

It is seen from these examples that not only considerations of moisture but of temperature also must be regarded in determining the adaptability of a species to any locality.

Generally speaking, none of our trees succeed as well in the highlands of the West as in the valleys, and the reason is evident. Aside from the great difference in soil moisture, the lower lands have, as a rule, a much deeper surface soil, and the atmosphere of the valleys is measurably protected from wind action, so that the evaporation is relatively less—a point second only in importance to the moisture supply. While it is true that few, if any, species grow as rapidly on

the higher land, some are comparatively successful there. On deep soils the black wild cherry, catalpa, white elm, honey locust, black locust, hackberry, bur oak, box elder, bull pine, Scotch pine, Austrian pine, and red cedar do well in places where the temperature is suitable. Perhaps no tree in the above list is more widely adapted to varying conditions than the Scotch pine, which seems to be equally at home in the dry prairies of eastern Dakota and northern Nebraska (longitude 100° W.), the clay soils along the Missouri, the limy loams of the Kansas River bluffs, and the sandy loams of the Arkansas Valley.

OBJECTIONS TO PLANTING SINGLE SPECIES.

Pure planting is a term applied to plantations of a single species. In nature this condition is seldom found in the West, except along rivers where a grove of willows or cottonwoods has sprung up, or in the mountains where the pines or the spruces often form by themselves dense forests.

Pure planting is not to be recommended on the plains for several reasons. In the first place, the trees, being all of the same species, have the same form and rate of growth. If any accident or insect injure them on a considerable area, the soil is at once exposed, and a weed growth quickly takes possession of it.

In the second place, all the trees demand an equal amount of light, and this causes a crowding that will result in the premature death of many. If the kind selected be a sparsely shading sort, such as cottonwood and the locusts, a rank growth of weeds and prairie grasses will spring up and rob them of soil moisture, thus checking their growth.

The various uses of the farm demand a variety of timbers. A pure grove, even though successful, will not be as valuable to the farmer as a mixed grove.

RULES FOR MIXED PLANTINGS.

In planting timber trees, whether the area to be covered is 5 or 5,000 acres, certain principles should govern the work. It is desirable that the kinds selected be adapted to a variety of uses, that the plantation make a good wind-break, and that the trees be brought to maturity at the least possible cost to the planter.

Having determined what varieties are suitable to the locality, the mixing of two or more kinds depends (1) on their relative capacity for preserving or increasing favorable soil conditions, (2) on their relative dependence on light and shade for development, and (3) on their relative height growth.

Based on these principles, the following rules have been formulated:

(1) The dominant species, that is, the one occupying the most of the ground, must be one that improves the soil; in the West a shade-making kind.

(2) Shade-enduring (densely foliaged) trees may be mixed together when the slower growing can be protected from the overtopping of the more rapid growing, either by planting the slower growing first or in greater numbers or larger specimens, or by cutting back the quicker growing ones.

(3) Shade-enduring kinds may be mixed with light-needing kinds when the latter are either quicker growing, planted in advance of the former, or larger specimens.

(4) Thin-foliaged kinds should not be planted in mixtures by themselves except in very favorable locations, such as river bottoms, marshy soils, etc., where no exhaustion of soil humidity need be feared, or on very meager, dry soils, where nothing else will grow.

(5) The introduction of individual light-foliaged trees is preferable to placing them together in groups unless special soil conditions make the occupation by one suitable kind more desirable.[1]

There are difficulties in the application of these rules to Western planting that will at once suggest themselves. The first is that among the species available to the farmer very few are shade enduring, and a second is that as the trees grow older they change somewhat in reference to their shade endurance. The black wild cherry, for instance, endures much more shade during its youth than after it has attained its principal height growth. It has here been included among the shade-enduring kinds with this understanding. It should also be remembered that moist soils increase the shade endurance of all species, and vice versa.

RELATIVE SHADE ENDURANCE.

Considering first the species that are most available in the West, a series arranged with reference to shade endurance would read about as follows: (1) Box elder, Russian mulberry (red cedar, Douglas spruce, white spruce, Norway spruce); (2) black wild cherry; (3) hackberry; (4) silver maple; (5) bur oak; (6) green ash, catalpa (Scotch pine, bull pine); (7) black walnut; (8) honey locust; (9) black locust (larch), and (10) cottonwood.

The best shade-enduring variety probably is the sugar maple. In the Dakotas and northern Nebraska the box elder answers tolerably well during youth, and is unquestionably the most available species for this purpose. Farther south the Russian mulberry may be substituted.

The relative shade endurance of the conifers is indicated in parentheses in the above list, for the reason that the high prices charged for such trees have thus far prevented their extensive use in Western tree planting. For the same reason they have been given a much less important place in the planting schemes which follow than would otherwise have been warranted.

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[1] See annual report of Division of Forestry, 1886.

At least two-thirds of the plantation should be of dense-shading trees, among which the light-demanding species should be planted singly, so that each tree will be surrounded by shade-enduring kinds. To insure the greatest degree of success three-fourths or more of the grove should be shade-enduring kinds.

The special importance of completely shading the ground as soon as possible in Western tree culture is the necessity of preventing grass growth. The prairie grasses are exceptionally vigorous growers, and are all light-demanding species. Once established, it is difficult to eradicate them, and they seriously check the tree growth. Thousands of promising cottonwood groves have been ruined by permitting the grasses to get a foothold in the plantation. None of the light-foliaged trees make sufficient shade to prevent grass growth; so that the planter must either continue cultivation, which is too expensive a process, or use dense-shading trees for the major part of his grove. Indeed, the subject of light requirement is of the first importance in forest tree-culture anywhere. Heretofore it has received practically no attention in the West, and the above placing of species may have to be changed with more extended observation and experiment under Western conditions.

RATE OF DEVELOPMENT.

The varieties to be mixed should be chosen not only with reference to their light requirement, but also to the period of their development or rapidity of growth. To the Western planter shelter from winds is the most important object to be attained, and in order to accomplish this at the earliest possible time the majority of the trees should be quick growers. It seldom happens that rapid growers yield a timber valuable for economic uses, the catalpa and black locust being notable exceptions, and they can only be grown in a restricted territory. The cottonwood grows faster than any other Western species, but it is valueless for home use except as fuel, and it is of the poorest quality even for that purpose. The box elder and soft maple are but little better. These are trees of the earliest maturity, and the two last named are among the most available shading kinds. Cottonwood is almost useless in mixed planting. The plantation, then, should be made up largely of these quickly maturing species, even though they are of but slight economic value. Distributed singly among them should be trees of a slower rate of development, chosen also with a view to their light requirement. If one-half or two-thirds of the plantation be of box elder, for instance, at least half of the remaining trees should be of a shade-enduring kind, that will continue to keep down weed growth by keeping the soil shaded after the box elders are thinned out. The remainder of the species may be of high economic value and slower maturity, such as bur oak, black walnut, and ash, or they may be rapid growers which demand a great deal of light, such as black locust and catalpa, or they may be pines, or all these may be introduced, but

An inspection of the above diagram will show that the mulberry, catalpa, and black wild cherry, shade-enduring trees, constitute three-fourths of the planting, leaving the remaining fourth to light-demanding species; black locust, a rapid-growing tree and one of our very best post timbers, makes up one-half of the light-demanding species; green ash, white elm, and Scotch pine (for which ash could be substituted) each constitute one-fourth of the remainder, while bur oak and black walnut, at intervals of 12 by 24 feet, fill the remaining places. The mixture has been arranged with reference to the light requirement of the trees. Catalpa and mulberry alternate with each other in the rows, so that at the thinning time, if it is desirable to remove either, the other will protect the soil. The catalpa pushes late in spring and its leaves drop with the first frost, so that alone it is not a good nurse tree; but mixed with mulberry, which has an earlier and more persistent foliage, the defect is measurably overcome. The catalpa, grown close, will make poles in five to ten years, so that if at the first thinning this variety is removed it will give an abundance of room for the other trees—admitting light not only to its own rows, but to the more permanent trees adjoining it—and will yield a good return in sticks large enough for pole fencing, stakes, or stove wood.

When the catalpa is removed, the black wild cherry and mulberry will soon close the breaks made in the leaf canopy, and thus weed growth will be prevented. At the next thinning, in from fifteen to twenty years, the mulberry will be large enough to make from two to four posts per tree, or, if deemed more desirable, a part of the black locusts will be found large enough for use. By this time the cherries should average 30 to 35 feet in height, and it may be necessary to aid the oaks, either by removing the adjacent mulberries and cherries, or by cutting their lateral branches. All the trees will have been forced to grow tall and straight.

For the more northern part of the plains the number of species would have to be reduced or substitutions made, as experiments seem to indicate that the shade-enduring species are box elder and black wild cherry, and the light-demanding forms that have proved successful are white elm, green ash, bur oak, cottonwood, Scotch pine, and Austrian pine. Red cedar and the spruces are shade enduring, and the bull pine (*Pinus ponderosa*) of the Black Hills will doubtless be a useful addition to this list.

The white spruce or Douglas spruce could be substituted for catalpa, box elder for mulberry, and white elm for locust, increasing the number of green ash to 302 in place of the white elm indicated in the mixture; or, if only broad-leafed trees are to be used, the following mixture could be made:

B	B	B	B	B	B	B	B	B	B
B	A	B	C	B	E	B	C	B	L
B	B	B	B	B	B	B	B	B	B
B	C	B	L	B	C	B	A	B	C
B	B	B	B	B	B	B	B	B	B
B	A	B	C	B	E	B	C	B	O
B	B	B	B	B	B	B	B	B	B
B	C	B	L	B	C	B	A	B	C
B	B	B	B	B	B	B	B	B	B

B, Box elder; A, Green ash; C, Black wild cherry; E, White elm; O, Bur oak; L, Yellow birch.

On the basis of this diagram it would require per acre, planted 3 by 3 feet, the following number of trees of each species:

Box elder	3,630	White elm	201
Black wild cherry	607	Yellow birch	151
Green ash	201	Bur oak	50

In this mixture, box elder is used as the early maturing, dense-foliaged form, and constitutes three-fourths of the trees. They are so placed that the alternate trees in the solid box-elder rows may be removed, and the more permanent trees will still be surrounded by good shade-making kinds. Should all the nurse trees be removed, the black wild cherry, constituting one-half of the remainder of the plat, would become the dominant tree, and, being a shade-enduring kind, would act relatively the same as box elder. The cherries are so placed that if all the box elders were cut out, the lighter-foliaged forms would each be surrounded by cherries. The box elder will not make as useful a timber for any purpose as catalpa, but the latter species is not hardy north of central Nebraska, and grows poorly west of the ninety-ninth meridian in Kansas, so that it is only available in a comparatively small part of the West. The cottonwood is not recommended, as other and better trees can be grown in its place. The box elder grows rapidly only during its youth, and within ten or fifteen years the remaining trees may be expected to overtop it; but where fuel is as scarce as on the plains, even the first box-elder thinnings, at seven to ten years from planting, will be found very useful for firewood.

The black locust can be grown throughout Nebraska south of the sand hills, but it does not succeed in the northern part of the plain region, nor does the honey locust, though this will stand in the southern counties of South Dakota. The mixtures here suggested are given not as ideal ones, but to illustrate the practice. The important point to be observed is the necessity of having a good shade maker as the dominant tree in the beginning, and providing for a suitable distribution of the light-demanding species among the permanent shade-enduring kinds.

CONIFERS FOR WESTERN PLANTING.

The climatic conditions throughout the States between the Mississippi River and the Rocky Mountains seem to indicate that the cone-bearing trees are better adapted to the plains than are the broad-leafed species. The excessive evaporation of the plains, due in a great measure to the constant winds, is much more trying to deciduous trees than to evergreens, the foliage of which is especially designed to withstand it.

Experiments have been conducted in the cultivation of conifers in the West, but they have been almost invariably attended with only a small measure of success, or have failed entirely. The few exceptions, however, prove that it is possible to make certain of the conifers live, and that, once established, they thrive where broad-leafed trees fail (as in the sand hills).

It should be stated that as a people we are unfamiliar with the handling of young cone-bearing trees, but having had large experience, one way and another, with deciduous forms, we have a much better understanding of the requirements of the latter. Undoubtedly most of the failures with conifers in the West have resulted from ignorance on the part of the shipper, the buyer, and the planter. In digging deciduous trees but little care is necessary to protect the roots. Indeed, the writer has received a lot of oak trees the roots of which looked so dry that they were planted without any expectation of their growing, but only a small per cent of them failed; and others, notably the green ash and catalpa, will stand a great deal of abuse of this sort. The conifers, however, have a very different root system, and require different handling. Take almost all of the broad-leafed trees that thrive in the West, and in their seedling stage they have either a heavy taproot, like the catalpa, walnut, and ash, or several equally strong main roots springing from near the collar, which have but few rootlets. The conifers, on the other hand, have a mass of fine rootlets by the time they have attained a size for transplanting, and even were other things equal, these very fine roots would dry out much quicker than the larger roots of the broad-leafed trees.

The fact that the roots of young cone-bearing trees dry out quicker, with greater resulting injury, than those of other tree forms can easily be established by exposing elm or cherry and larch seedlings for a few hours and then planting them. The former will be none the worse for its sun bath, but the latter will fail to grow. The roots of cone-bearing plants should not be exposed to the drying action of the air from the time they are taken up until they are transplanted. As the young conifers are dug their roots should be plunged in water or puddled in mud. In the storehouse, during the interval of packing, they should be protected by damp moss. In transit they should be so packed as to avoid heating on the one hand, and drying out on the other. When received by the planter, they should at once be separated, puddled, or dipped in water, and carefully "heeled in"

(covered temporarily with moist earth) in a shaded location until they can be set. When the planting season arrives, a moist, cloudy day should, if possible, be chosen for the work, and the young trees should be taken from their temporary resting place and carried in vessels of water to the field.

In planting, none but fine moist soil should come in contact with their roots, and this should be tramped very firm, so that the fine soil will be brought into close contact with the rootlets. Then if an inch of loose soil be spread over the top, making the surface level and preventing drying out, the tree will have been well planted. The cone-bearing trees, as a rule, do not start so readily as the broad-leafed species. They have as great, if not a greater, supply of stored food, and push their buds vigorously, but the roots do not take hold of the soil so readily, new roots are not formed, and as a result the trees frequently perish after a seemingly excellent start has been made.

The conifers are of very great utility in Western planting. Being evergreen, they make far better wind-breaks than do the deciduous trees, and herein is their peculiar value. Tree planting on the plains, at least under existing conditions, can hardly be expected to assume the proportions of forest planting, and hence the economic value of the wood of pines and spruces is of minor importance. They do not furnish as strong lumber as do the ash and oak, and are not so durable in contact with the soil as black locust and catalpa; hence for the ordinary farm uses the timber of the conifers is not especially desirable.

FOREST PLANTING IN THE SAND HILLS.

An experiment in the planting of forest trees in the sand hills of Nebraska has been described in the annual reports of the Division of Forestry, and the results thus far attained seem to indicate that the first step in this direction will be the growth of Banksian pine on the sand ridges. These sand hills occupy approximately an area 250 miles long (east and west), and from 50 to 70 miles across. The country is traversed in all directions by high hills composed of almost pure sand, interspersed with grassy valleys which are good grazing and hay lands. The hills are covered with a sparse growth of grasses and weeds, scarcely enough to bind the sands, which are frequently blown out in large areas, often making great holes a hundred yards in diameter in the sides of the hills. The wind and blowing sand make the valleys almost uninhabitable, and even were these difficulties removed the soil of the valleys is very shallow, and will not long bear cultivation. The experiment undertaken by the division had for its object the determination of what species would grow on these sand hills.

Without going into details, which have been already reported, it may be said that of a number of species of deciduous and coniferous trees planted only one shows decided adaptability to this unfavorable

locality. The Banksian pine, planted on the highest ridges in the heart of the sand hills four years ago, seems thus far well suited with its surroundings; all the deciduous trees are dead, and only a few ponderosa, Scotch, Austrian, and red pines remain. The land was not plowed, as such a procedure would have caused it all to blow away. Furrows 2 feet apart were turned, and the little trees, 6 to 10 inches high, were planted in these furrows so as to be slightly shaded by the ridges formed in making them. The Banksian pines are now from 18 inches to 4 feet high, and are each year growing more than the last. The sand of which the hills is composed is fine, like clean river sand, and during the driest seasons moisture can be found only a few inches below the surface. If this great area, lying almost midway between Texas and the British Possessions, could be covered with forest trees, a noticeable improvement in the climate of the plains would result.

From the action of the other species of pine noted it is safe to infer that after the Banksian pines are a few feet high, and able to afford slight protection, other and more valuable species can be grown in their shade. The Douglas spruce (*Pseudotsuga douglasii*) has not stood as well as the pines in this experiment, nor is this surprising when the greater shade endurance of this species is recalled. It is reasonable to hope, however, that this valuable species can be established in the shade of the Banksians, and that once established it will serve as an excellent nurse for the more rapid-growing pines. After these have been cut off the spruce will be left as the dominant trees.

Every forest experiment in the sand hills should have as its ultimate aim an extent great enough to warrant systematic management, conducted on the general principles laid down in the annual report of the Division of Forestry for 1891. Judging by the action of the trees in the Nebraska sand hills experiments thus far, the following diagram illustrates what might be a safe planting scheme:

B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P

Distance between trees, 2 feet each way. Number of trees to the acre, 10,840, of which 6,775 are Banksian pine, 2,710 Douglas spruce, and 1,355 pines of one or more of the following species: *Pinus ponderosa*, *P. sylvestris*, and *P. resinosa*.

The Banksian pines would only be expected to stand until the others were established, and could be given the start by two or three years.

From the action of the trees in the Nebraska experiment, it would seem that the Douglas spruce, if used at all, should not be set until at least three years after the Banksians. In case the spruce is omitted entirely, the Banksian should be set in its place.

GENERAL CULTURAL NOTES.

With the exception of the sand hills, general suggestions may be made which will be applicable to the cultivation of forest trees throughout the plains.

Preparation of the soil.—In the preparation of the soil too much importance can not be attached to depth of plowing. The Western prairies, through long exposure to the action of the elements and to the tramping of the countless herds of buffaloes, which for centuries found in them a favorite pasture ground, have become far more compact than the forest-protected soils of the East. After a prolonged drought, such as frequently occurs, the autumn rains are not readily absorbed by the hard soil, and much moisture that might be saved to crops runs off and is lost to the fields. This is particularly true of the western parts of Nebraska and Kansas, and eastern Colorado. The same lands under deep tillage act very differently. Not only is the absorbing power of the soil increased by deep plowing, but the ability of such soil to retain moisture, under proper culture, is marked.

Land should be gradually prepared for tree planting by increasing the depth of plowing during three successive years, if so much time can be given to the work. The usual practice in the West is to break the land in June or July, turning as thin a sod as possible, and laying it flat, for which purpose the breaking plows are well adapted. Sometimes, on early breaking, a crop of sod corn or flax is grown the same year. After one crop is removed, the land is backset, when an inch additional is turned. For tree planting the depth should be increased from 2 to 3 inches at a time, until at the end of the third year the land may be plowed 10 to 12 inches deep. The advantage of this gradual preparation is in the complete subjection of the native growth of grasses and other herbaceous plants. This is a most important point in the economic growing of trees on the plains. If the native growth is entirely subdued, so that no live grass roots are present in the soil when the trees are planted, a great deal of after-labor is obviated.

One of the most obvious difficulties in the way of successfully meeting the requirements of the timber-claim law, which resulted, in spite of its defects, in so much good to the Western States, was the short time allowed between breaking the prairie sod and planting the trees. It was almost impossible under the methods of farming in vogue in the West to kill out the native vegetation in two seasons, but by gradually increasing the depth of plowing and by planting hoed crops the season preceding the setting of trees, the land can be completely

subdued. Deep-plowed land will absorb much more of the melting snows and the spring rains than shallow-plowed land with the compact underclay within a few inches of the surface. By the time the planting season opens, in a year of ordinary rainfall, a deep-plowed field will be in excellent condition to receive the trees so far as moisture is concerned.

Thorough pulverizing of the soil is but little less essential, as a preparation for trees, than deep plowing. The particles of the soil should be fine in order that they may be brought in close contact with the roots of the trees, and thus supply them with moisture. If the field is rough and full of clods, the land will dry out rapidly. The thorough use of the disk harrow, clod crusher, pulverizer, and smoothing harrow is quite as important in preparing land for trees as in the preparation of a field for a crop of wheat. Not only will trees start more quickly when set in well-prepared soil, but the growth will be more uniform and strong.

As in all other hoed or cultivated crops, it is important to keep the surface of the soil in fine tilth until the trees have grown sufficiently to shade the ground. Deep plowing and shallow cultivation should be the rule in all kinds of Western farming. The deep plowing gives a large absorptive area, and shallow cultivation places over the moist soil a dust blanket that acts as a most effective mulch, checking evaporation and thus retaining the soil-moisture for the use of the trees. The Western planter must keep constantly in mind the necessity of saving, by every possible means, the moisture of the soil. In the Eastern States, which have a well-distributed rainfall of from 30 to 50 inches, this is a point of comparatively little consequence; but beyond the Mississippi its importance increases as one goes westward.

Planting trees.—In planting trees careful alignment will save much labor in cultivation. It will pay to mark the land as carefully as for corn where groves of 10 acres or less are to be set, and to begin planting all the rows from the same side of the field, as the slight deviation resulting from pressing the spade forward in planting will thus bring all the trees in even crossrows. Almost all seedling forest trees can be set with a broad dibble or spade, which is sunk blade deep at the cross mark, the soil pressed forward, the roots so inserted as to avoid turning the tip upward, and the soil pressed firmly about the collar with the feet, brushing a little loose dirt over the pressed places to prevent baking. When planting in this way, the seedlings can be carried in a pail with a little water or moist earth. In mixed planting it will be found most convenient to set all the trees of the prevailing species first, leaving the places for the kinds that are to be used in smaller quantity to be planted afterwards. Where two or three shade makers are used the same method can be followed, or each kind may be handled by a different planter, all working together.

It is also desirable to take all the trees to the plat to be planted

and heel them in where they can be easily reached. Special care should be taken to prevent the drying of the roots of conifers. Where the roots are large and fibrous, it will be found best to dig a hole for the trees, setting them in the same manner that orchard trees are planted. Care should be taken to secure perfect alignment in this method, as when the rows are irregular it is impossible to bring the cultivator close to the trees.

Exposure of roots.—It occasionally happens in the West that during the early summer, or after the leaves have dropped in the fall, the surface soil will be blown away by the hard winds, exposing the roots to the drying atmosphere. To prevent this, the trees should be set an inch deeper than they grew in the nursery, and in autumn, after the leaves have fallen, a shallow furrow should be turned to the trees, so as to throw the dirt against the trunk. This can be done with the shovel attachments of the ordinary wheel hoe, which is one of the most useful implements that can be used in the young tree plantation.

Cultivation.—The amount of cultivation beneficial to young trees can not be determined by freedom from weeds, nor by the number of times the operation is performed. In seasons of prolonged drought frequent stirring of the surface soil will be found of great benefit, as it will keep over the surface a layer of loose, fine earth, which will quite effectively check evaporation from the moist soil below. After rains the stirring of the surface soil will prevent the formation of a crust, which indicates the too rapid loss of water from the soil. Weeds and grass should be kept out of the trees, because they use the moisture that will be needed for tree growth. Ordinary shallow cultivation will be found sufficient for annual weeds—including the Russian thistle, sunflower, and mustard—if begun early and continued regularly, but the only way to get rid of the couch grass (*Agropyrum repens*) is to carefully dig out its underground stems and remove them. It is well to be on the watch for this pest, for when once established among trees it is almost impossible to eradicate it.

Cultivation should cease at midsummer, in order not to encourage too late growth and consequent danger of winterkilling. Thereafter large weeds can be cut out with a hoe, or a thin crop of oats or buckwheat can be sown among the trees to hold the soil during the drying winds of late summer and early autumn. After the leaves fall, a shallow furrow turned against the trees will prevent exposure of the roots by the late fall and early spring winds.

The best implement for cultivating young trees is a harrow-tooth culivator. The horse hoe, with its varied attachments, is useful in the tree plantation, as well as in the fruit and vegetable garden. During the first year a two-horse cultivator can be used, but it should always work shallow; the result, however, is not so satisfactory as with the finer-toothed machine.

trees for almost the first time since 1879 or 1880 (figs. 83 and 84). The white-marked tussock moth, the caterpillar of which has been for many years the most serious of the shade-tree pests in Philadelphia, New York, Brooklyn, and Boston, in 1895, for the first time within the recollection of the writer appeared in such numbers as to become of great importance in more southern cities, as Baltimore and Washington. The fall webworm (figs. 91, 92, and 93) was more abundant in Washington and the surrounding country than it has been since the summer of 1886.

These four insects are the principal shade-tree defoliators in the Eastern States, if we except the imported gypsy moth, which is at present fortunately confined to the immediate vicinity of Boston, and is being cared for by a thoroughly capable State commission. While the summer of 1895 may with justice be called an exceptional one as regards the great increase of numbers, yet these insects are always present and do a certain amount of damage each season, and when an exceptional season comes, as it did this year, city authorities seldom find themselves prepared to engage in an intelligent and comprehensive fight.

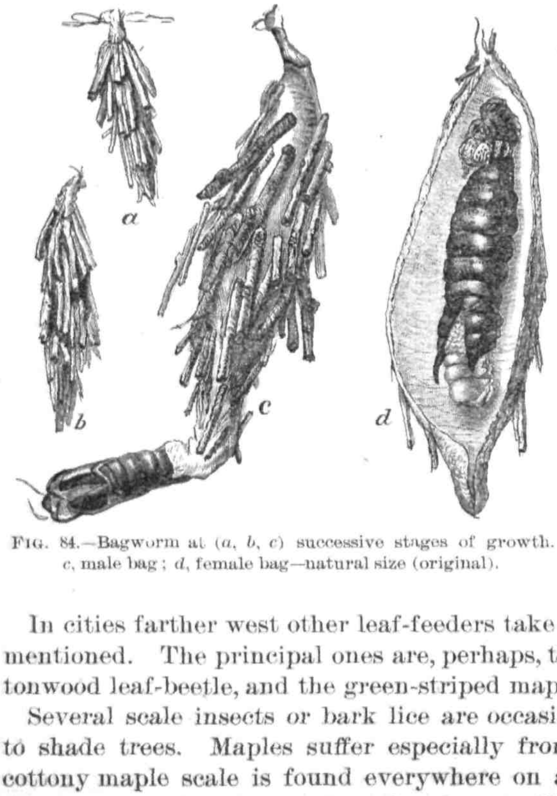

FIG. 84.—Bagworm at (*a*, *b*, *c*) successive stages of growth. *c*, male bag; *d*, female bag—natural size (original).

In cities farther west other leaf-feeders take the place of those just mentioned. The principal ones are, perhaps, the oak Edema, the cottonwood leaf-beetle, and the green-striped maple worm.

Several scale insects or bark lice are occasionally serious enemies to shade trees. Maples suffer especially from their attacks. The cottony maple scale is found everywhere on all varieties of maple, and occasionally in excessive abundance. The cottony maple-leaf scale, a species imported from Europe, is rapidly gaining in importance, and in several New England towns it has, during the past season, seriously reduced the vitality of many trees. The so-called "gloomy scale" has long been on the increase in Washington, D. C., and every year it kills large branches and even entire trees of the silver maples, which are so extensively grown along the streets of that city.

Certain borers are also occasionally destructive to many shade trees, and, in fact, in the northern tier of States, these are the most important of the shade-tree enemies, the principal leaf feeders being either absent or becoming single brooded. Where absent their places are taken by less destructive species.

In fact, it is safe to say that shade trees suffer especially from insect attack throughout the region of country which is contained in the Upper Austral life zone.[1]

Concerning the borers, it may be briefly said that these insects rarely attack vigorous and healthy trees, but should a shade tree lose its health through the attacks of scale insects, through rapid defoliation by leaf feeders, or through a leaky gas main or sewer pipe, different species of borers will at once attack and destroy it. There is one particular exception to this rule, and that is the European leopard moth, a most destructive species, which is at present of very limited range and confined to the immediate vicinity of New York City. No certain information is at hand which indicates that it has spread for more than 50 miles from the center of introduction. This insect attacks healthy trees, boring into the trunks of the younger ones, and into the branches and smaller limbs of many shade and fruit trees. It is an extremely difficult species to fight, and it is fortunate that its spread is not more rapid.

THE IMPORTED ELM LEAF-BEETLE.

(*Galerucella luteola* Müll.)

Original home and present distribution.—The imported elm leaf-beetle (fig. 85) is a native of southern Europe and the Mediterranean islands. It is abundant and destructive in the southern parts of France and Germany, and in Italy and Austria. This beetle is found, though rarely, in England, Sweden, and north Germany, and gradually becomes less numerous and destructive toward the north. In middle Germany it is common, though not especially destructive. As early as 1837 it was imported into the United States at Baltimore, and is now found as far south as Charlotte, N. C. From this point it ranges northward in the Atlantic cities as far as Providence, R. I. Inland it has not passed the barrier of the Appalachian chain of mountains, and is practically confined to the Upper Austral region, as indicated in the map on page 210 of the Yearbook for 1894. Thus, up the Hudson River it has spread to Albany, N. Y., but on either side of the river, as the land rises into the foothills, it has stopped. In the same way it has more recently spread up the Connecticut River Valley to a point north of the New Hampshire State line, and also, to a less extent, up the Housatonic Valley. From our present knowledge it

[1] Briefly defined by Dr. Merriam in his summary article on "The geographic distribution of animals and plants in North America," in the Yearbook of this Department for 1894, page 203.

seems likely that its future spread as an especially destructive species will be limited by the northern border of the Upper Austral region, and that (as may happen at any time) should it once be carried by railway train across the southern extension of the Transition life zone, caused by the Alleghany and Blue Ridge mountains, it will spread unchecked through Ohio, Indiana, Kentucky, Tennessee, and other Western States.[1]

Food plants.—No food plants other than elms are known. The common English elm (*Ulmus campestris*) is its favorite food, and the gardener's variety, the so-called Camperdown, or weeping elm, is attacked with equal avidity. The American, or white, elm (*U. americana*) ranks next among the favored species, with *U. montana*, *U. suberosa*, *U. flava*, *U. racemosa*, and *U. alata* in about the order named. No variety seems absolutely exempt. In the presence of *U. campestris* other elms are seldom seriously injured. Where *campestris* is absent, or where a single tree of *campestris* is surrounded by many American elms, the latter become seriously attacked.[2]

Life history and habits.—The elm leaf-beetle passes the winter in the adult, or beetle, condition in cracks in fences or telegraph poles, under the loose bark of trees, inside window blinds in unoccupied houses, in barns, and, in fact, wherever it can secure shelter. As soon as the buds of the trees begin to swell in the spring the beetles issue from their winter quarters and mate, and as soon as the buds burst they begin to feed upon the leaflets.

This feeding is continued by the beetles until the leaves are fairly well grown, and during the latter part of this feeding period the females are engaged in laying their eggs. The eggs (fig. 85, *c*) are placed on the lower sides of the leaves, in vertical clusters of 5 to 20 or more, arranged in two or three irregular rows. They are elongate oval in shape, tapering to a rather obtuse point, orange yellow in color, and the surface is covered with beautiful hexagonal reticulations. These reticulations, however, can be seen only with a high magnifying power.

The egg state lasts about a week. The larvæ (fig. 85, *d*) as soon as hatched feed on the under surface of the leaf, gradually skeletonizing it. They reach full growth in from fifteen to twenty days, and then either crawl down the trunk of the tree to the surface of the ground or drop from the extremities of overhanging branches. At the surface of the ground they transform to naked, light orange-colored pupæ (fig. 85, *g*), a little over a quarter of an inch in length, and in this stage they remain for from six to ten days, at the expiration of that time

[1] Since this was written the writer has learned that this passage of the Blue Ridge barrier has actually taken place during the past season. Mr. A. D. Hopkins, of the West Virginia Agricultural Experiment Station, has found that this insect has established itself at Elmgrove, in Ohio County, and at Wellsburg, in Brooke County, W. Va.

[2] The beetles rarely oviposit upon *Zelcova carpiniafolia* and *Z. acuminata* on the Department grounds at Washington.

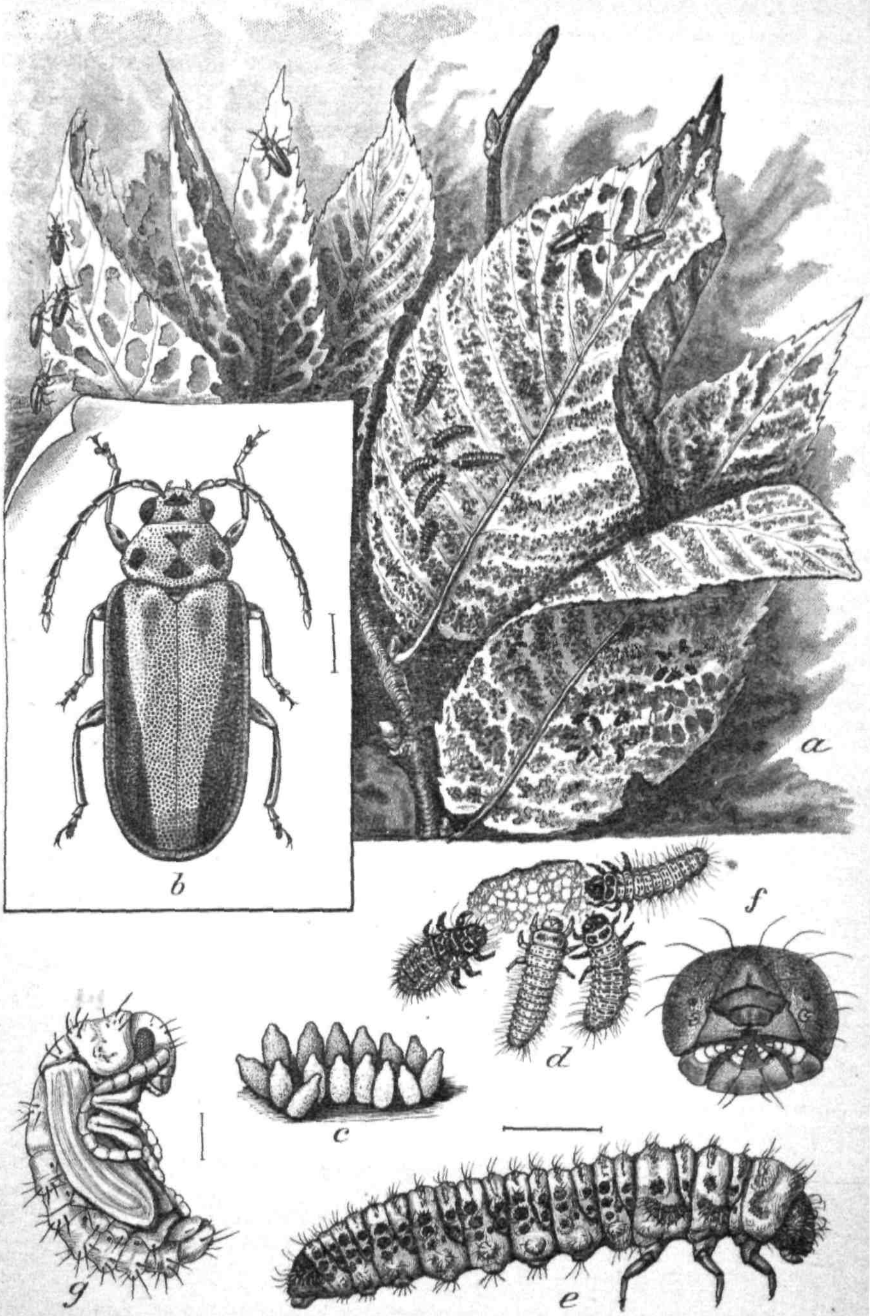

FIG. 85.—The imported elm leaf-beetle (*Galerucella luteola*). *a*, foliage of European elm showing method of work of beetle and larva—natural size; *b*, adult beetle; *c*, egg mass; *d*, young larva; *e*, full-grown larva; *g*, pupa—all greatly enlarged; *f*, mouth parts of full-grown larva—still more enlarged (original).

transforming to beetles. The pupæ will frequently be found collected in masses at the surface of the ground in this way. On very large trees with shaggy bark many larvæ will transform to pupæ under the bark scales, or on trees of the largest size they may descend the main branches to the crotch and transform unprotected in the hollow of the crotch.

The larva is elongate, reaching when full grown (fig. 85, *e*) half an inch in length. When first hatched it is nearly black; as it increases in size it becomes, with each shedding of the skin, more distinctly marked with yellow, and when mature the yellow predominates, occurring as a broad dorsal stripe and two lateral stripes.

The difference between the early work of the beetles and the later work of the larvæ is recognized at a glance. The beetles eat entirely through the leaves and make complete, irregular holes, while the larvæ simply eat the parenchyma from below, skeletonizing the leaf.

The time occupied in egg laying is long, and it thus happens that at the time when full-grown larvæ, and even pupæ, are to be found there are also upon the leaves freshly laid eggs.

In Washington there are invariably two generations annually, the beetles developed from the eggs laid by the overwintered beetles themselves laying their eggs in July. The adults issuing from these eggs make their appearance in August. Farther north, at New Brunswick, N. J., and in the Connecticut cities, it may be said that there is normally a complete first generation and an incomplete second generation.

The proper food of the larvæ is the rather young and tender leaves. If the work of the first generation has not been complete, and the trees have not been so nearly defoliated as to necessitate the sending out of fresh leaves, or if a period of drought ensues after defoliation and prevents the putting out of a second crop of leaves, the beetles of the first generation do not lay eggs, but after flying about for a time seek winter quarters. This may occur as early as the middle of July. Where, however, defoliation has been complete and has been followed by a period of sufficient moisture to enable a tree to put out a fresh crop of leaves, the beetles of the first generation will lay their eggs and a second generation of larvæ will develop upon this comparatively tender foliage. Where similar conditions prevail in Washington and its vicinity, a third generation of larvæ may develop, though small in numbers, but the writer is convinced that even in Washington late-developing beetles of the first generation may hibernate.

Remedies.—The only thoroughly satisfactory safeguard against this insect consists in spraying the trees with an arsenical solution. The only other remedy which is worthy of mention is the destruction of the larvæ at the surface of the ground before or after they transform to pupæ. The latter remedy, however, is not complete, and even

where it is carefully carried out for every tree in a city it will do no more than reduce the numbers of the insects by perhaps two-thirds.

Ten years ago a proposal to spray the enormous elms which are to be found in many northern towns would have been received with ridicule, but of recent years the practicability of the plan has so frequently been demonstrated that there is no hesitancy in commending it to more general city use. Probably the largest elm tree in America, the Dexter elm, at Medford, Mass., has been successfully and economically sprayed by the Gypsy Moth Commission. It is necessary to have especial apparatus constructed, and it is equally necessary to have the work done by men who are accustomed to it or at least are good climbers. The first successful work of this kind was probably that done by Prof. John B. Smith on the campus of Rutgers College. He had a strong barrel pump, and carried the nozzle at the end of a long rubber tube, with a bamboo extension pole, up into the center of the trees by climbing a ladder to the main crotch. From this point the spray was thrown in all directions, and the tree was thoroughly coated with the mixture in a minimum of time.

The Gypsy Moth Commission, in their earlier spraying work, sent their large tank carts through the streets, stopping at each tree and sending one or more men with hose and extension poles into it, thus covering hundreds of large trees in a single day. If steam sprayers are used (and the town or city fire engines can be and have been used to excellent advantage in this way), the necessity for climbing the trees may be largely avoided. By means of multiple discharge hose both sides of a tree, or even of two trees, may be sprayed at once, and the extent of territory that may be covered in a day is surprising. The elm trees in a small park may be treated economically and without much difficulty by two or three men with a hand-cart tank. This method has been adopted on the large grounds of the Department of Agriculture with absolute success.

The writer's experience at Washington leads to the conclusion that it is important to spray trees once just after the buds have burst. This spraying is directed against the overwintered beetles. If a large proportion of these beetles can be destroyed by poisoning the leaves which they eat, not only will a great deal of leaf perforation by the beetles themselves be prevented, but the number of eggs laid will be very greatly lessened. A second spraying should be conducted two weeks later. This is directed against the larvæ, the majority of which will perhaps have hatched by that time or soon after. A third spraying, and even a fourth, or under exceptional circumstances a fifth, may be required if it is considered necessary to keep the trees fresh and green, and particularly if the earlier sprayings have been followed by rains, as is apt to be the case in the earlier part of the season. In Bridgeport, Conn., where only a part of the trees are sprayed, and these by private enterprise, an even greater number of operations

have been found desirable. Three thorough sprayings of all the trees in a given precinct will probably be as much as will be required, especially if this be done year after year and some pains be taken to destroy such of the larvæ as may successfully develop and descend for transformation. Even two sprayings, covering all the elms of a city or town, will be well worth the expense.

The substance to be used in these spraying operations may be paris green, london purple, or arsenate of lead. The directions for the use of these substances have been so often repeated that it is not worth while to mention them here.

The other remedy—the destruction of the descending larvæ and the quiescent pupæ—is, as above stated, and must always be, incomplete. The standard kerosene emulsion, diluted one part to five parts of water, will destroy the insects in either of these stages. This has been successfully used in several New England towns the past season, particularly in New Haven. It must be applied to the base of the trunk and under the entire limb spread of the tree. The rough bark must be removed to a slight extent (the writer does not advocate severe scraping), leaving as few crevices as possible which may harbor the pupating insects. If a tree is very large, it will pay occasionally to climb into the main crotch and destroy such individuals as may have collected at that point. Experience leads us to the estimate that on large trees not more than one-half to two-thirds of the larvæ reach the base of the trunk and transform at that point. The extent to which larvæ drop from overhanging branches has been questioned, and it is sometimes a difficult matter to decide. The city forester of Springfield, Mass., however, called our attention to a peculiar and eminently satisfactory case where the drooping branches of a large elm extended completely over a house, on the other side of which there were no elm trees. On the far side of the house, beneath the tips of the overhanging branches, the larvæ and pupæ were collected in large numbers in the summer of 1895.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* Smith and Abbot.)

Original home and present distribution.—This insect is a native of North America. It ranges from Jacksonville, Fla., to Nova Scotia, on the eastern coast, and extends west certainly as far as Keokuk, Iowa, and probably farther, although the records at command include no actual captures beyond this point. It does not occur in California, so far as learned.

Food plants.—It attacks almost every variety of shade, fruit, and ornamental trees, with the exception of the conifers. In the city of Washington it seems to select by preference the poplars, soft maples, the elms, alders, and birches, as well as the willows. It is also found here on apple, pear, cherry, plum, peach, other varieties of maple,

locust, box elder, ash, catalpa, rose, horse-chestnut, persimmon, sycamore, mulberry, and a number of other trees.

Life history and habits.—This insect passes the winter in the egg state. The overwintering eggs are laid by the female moth in the latter part of September, in a glistening white, frothy-looking mass attached to the outside of the cocoon. They are seen at a glance, owing to their pure white color, and remain conspicuously upon the trees until spring. The caterpillars hatch in Washington in April and May. They are

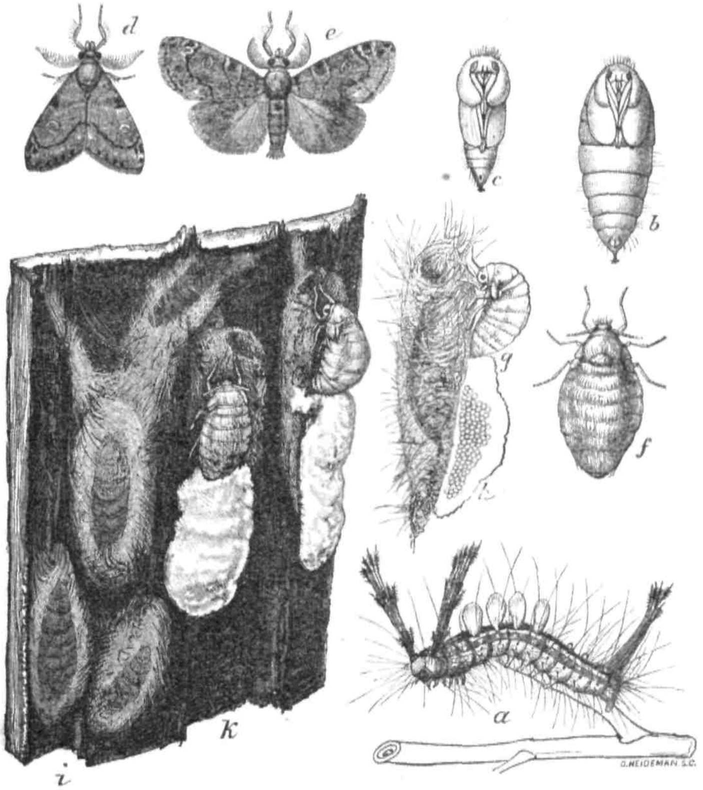

FIG. 86.—*Orgyia leucostigma.* *a*, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass, *i*, male cocoons; *k*, female cocoons, with moths carrying eggs—all slightly enlarged (original).

represented at different stages of growth in figs. 86, 87, and 88, and in view of the care with which these figures have been drawn detailed descriptions will be unnecessary. They cast the skin five times, exhibiting a different character after each molt, as indicated in the figures. The newly hatched young feed on the under surface of the leaf, eating off the parenchyma and producing a skeletonized appearance. After the first molt the skeletonizing continues, but a few holes are eaten completely through the leaf; after the second molt many

holes are eaten through between the main ribs, and after the third molt the leaf is devoured, except for the midrib and its principal branches. After the fourth molt the caterpillars begin to eat from the edge of the leaf and devour everything except the principal veins. Similar work is done in the last stage upon the full-grown and tough leaves (see fig. 89).

A most peculiar kind of damage by the caterpillars of this species has been observed by Dr. Lintner in Albany, N. Y. There, in the summer of 1883, he found that the tips of many twigs were girdled by the caterpillars, which had entirely removed the bark for a tenth of an inch. Such twigs broke off and fell to the ground, with their leaves. This damage was so common in 1883 that the sidewalks of the streets and public parks wherever the American elm was growing

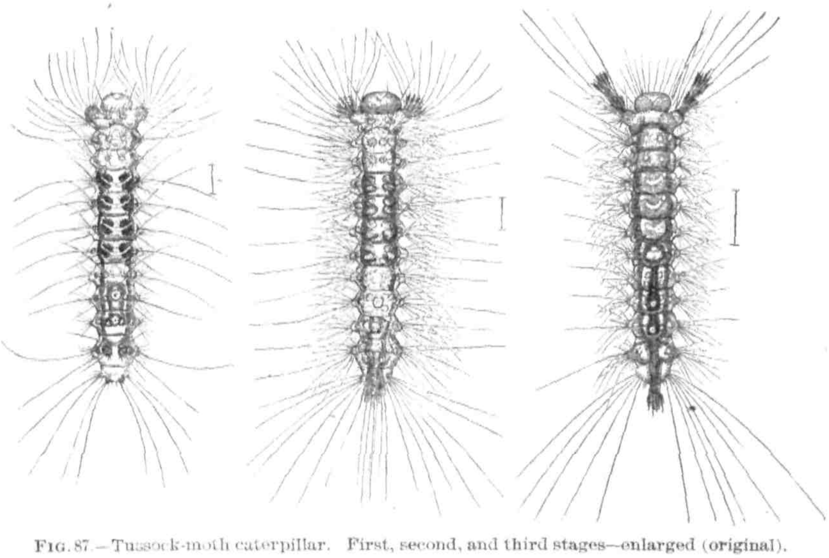

FIG. 87.—Tussock-moth caterpillar. First, second, and third stages—enlarged (original).

were sprinkled with the newly fallen leaves. Dr. Lintner was of the opinion that a cold spring and the sudden advent of warm weather caused an unusually vigorous growth of the terminal twigs, and that the young tips were therefore unusually tender. They thus proved appetizing to the tussock-moth caterpillars, which developed a new habit for the occasion. This peculiar damage was repeated in 1895, but to a less extent. No other observer in any part of the country has ever reported similar damage.

The young caterpillars drop down, suspended by silken threads, at even a slight jarring of the tree, and frequently spin down without such disturbance, and are blown to a considerable distance by the wind. When nearly full grown they are great travelers, crawling down the trunk of the tree upon which they were hatched and across

a considerable stretch of ground, to ascend another tree. When they occur in numbers, an extensive migration will always take place from a tree which has been nearly defoliated, and the species spreads mainly, if not entirely, in this way. Just as is the case with the gypsy moth, the caterpillars are carried by vehicles, upon which they crawl or drop, or upon the clothes of passers-by, and in this way many trees upon which there were no egg masses become infested.

The larval state lasts, on an average, from a month to five weeks. When full grown, the larvæ spin delicate grayish cocoons of silk mixed plentifully with hairs. The mixture of hair is brought about by the fact that the hairs are barbed and rather loosely attached to the body.

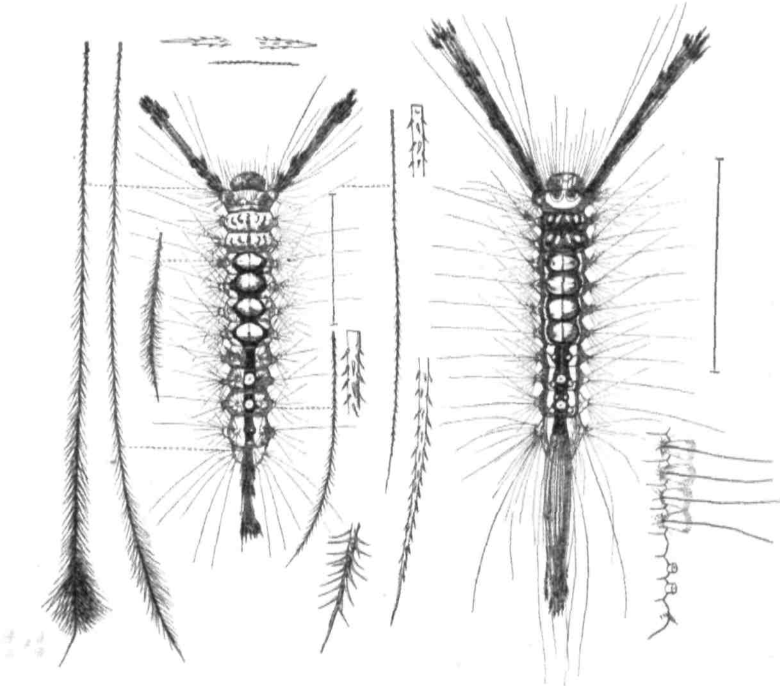

FIG. 88.—Tussock-moth caterpillar. Third and fourth stages, showing enlarged hairs from different parts of body (original).

When a caterpillar begins to spin its cocoon, the hairs of its body and those of the long, black tufts on the prothorax first become entangled with the silken threads and are pulled out. By the time the cocoon has begun to take shape, the characteristic long, black tufts of hair have entirely disappeared from the body of the caterpillar. Later the shorter hairs of the sides of the body become entangled and removed, and finally many of the hairs composing the brush-like tufts upon the fore part of the body are pulled out, and just before it transforms to pupa the caterpillar bears but a remote resemblance to the individual before it began to spin.

The barbed hairs just mentioned may occasionally produce considerable irritation of the skin of people upon whom the caterpillars may have crawled or dropped from the trees. The hairs from the different portions of the body of the full-grown caterpillar are illustrated, greatly enlarged, in fig. 88, and it is the shorter hairs from the sides which probably cause the irritation. They are very small, fall out readily, and when a caterpillar crawls over the skin of an individual who is warm and perspiring, these very sharply barbed hairs produce an irritation which in some individuals has been the cause of much discomfort, creating more or less inflammation and swelling.

The larva transforms to pupa within a few hours after the completion of the cocoon, and remains in the pupal condition from ten days to two weeks. The cocoons of this first generation, while mainly spun on the trunk and larger branches, are also spun to a very considerable extent upon the smaller branches and twigs, and even on the partly eaten leaves.

The adult insect presents the rather unusual phenomenon of a winged, active male and a degraded, absolutely wingless female. It is this fact which makes the spread of the species dependent upon the traveling powers of the caterpillar, as mentioned in the preceding paragraph. The male and female pupæ and the male and female moths are so well shown in fig. 86 as to need no description.

Coupling takes place upon issuing from the cocoon, and immediately afterwards the females begin to lay their eggs, clinging firmly to the cocoons from which they have issued and attaching the egg mass to the lower half of the cocoon, in the manner shown in fig. 86, *h* and *k*. As soon as the eggs are laid the females die, and usually fall to the ground, although sometimes their shriveled bodies remain, clinging by the legs to the upper part of the cocoon.

We have made no observations as to the duration of these midsummer eggs. Unfortunately, upon the length of time which elapses before hatching depends exact information as to the number of annual generations. Specific observations the past season in Washington were not begun until August 15. At that time the egg masses were everywhere to be seen, and about that time the eggs began to hatch. From the early statements of Riley it was assumed that these were the eggs of the second generation, but reference to the notebooks of the office shows that on several occasions overwintered eggs have hatched in Washington in April, and adults have issued as early as the middle of June. From the middle of June to the middle of August is certainly long enough to allow for a generation of this insect. Assuming that such a generation had developed, larvæ from these August eggs would belong to the third generation. This, however, is to a certain extent guesswork, and the regrettable lapse of observations during the last half of June, the whole of July, and the first half of August can be remedied only in another season.

Elaborate observations were made upon this August brood, the individuals of which were present in extraordinary numbers. Certain of the larvæ under observation, which hatched on August 2, commenced to spin up on September 3, and on September 14 the first male moths made their appearance, the first females issuing September 19. During the latter part of September the bulk of the moths issued, and the conspicuous white egg masses were very abundant by the 1st of October. Many of these egg masses were kept under observation from that time on. In the cold room of the insectary (temperature the same as outdoors) a few eggs hatched about the close of the second week in October, and on October 23 two newly hatched larvæ were observed upon an egg mass collected out of doors. This late fall hatching, however, is probably exceptional, but in a late, warm autumn it is likely to be rather general. It is hardly to be supposed that any individuals hatching after the 1st of October will successfully transform. The cocoons of this late fall generation are almost invariably spun upon the trunk of the tree and in the crotches of the main limbs, but occasionally, in the case of large trees, upon the larger limbs themselves. The tendency of all the larvæ of this generation is to crawl toward the ground before transforming. Cocoons are occasionally spun upon fences or other objects near the trees upon which the larvæ have been reared, but the vast majority are found upon the trunks.

There are, then, certainly two, and probably three, annual generations at Washington. In New York and Brooklyn there are two well-marked generations. At Boston, as is learned from Mr. Samuel Henshaw, there are two generations. Farther north, however, although the statement is based upon no exact observation, it is not at all likely that there are more than one, and, as stated in the introduction, the comparative harmlessness of the species in such regions is probably due to the nondevelopment of the second generation.

Remedies.—There are two classes of remedies as well as an excellent preventive that may be used to advantage against this insect. These are the collection or destruction of the eggs in the winter, spraying the trees against the larvæ, and banding unattacked trees to prevent the ascent of the caterpillars and the subsequent development of moths and the laying of eggs.

The collection and destruction, or the destruction without collecting, of the eggs must be thorough in order to have any practical efficacy. The great majority of the hibernating egg masses are deposited low down on the trunk of the tree or upon the main limbs, so that they can be reached in one way or another without much difficulty. The egg mass is compact, and, being attached to the somewhat flimsy cocoon and not to the bark, it is easily removed either by hand or by scraping it off. The egg masses which have been scraped off must not be allowed to remain at the surface of the ground, but

should be collected and burned. A scraper for the removal of egg masses which occur too high to be reached by hand has been devised by Mr. Southwick, of Central Park, New York City, and consists of a very small hoe blade at the end of a long pole. Perfectly unskilled labor can be utilized in this operation, but the workman should be impressed with the necessity of absolute thoroughness; not an egg mass should be overlooked. In the work against the gypsy moth in Massachusetts it has been found that the egg masses can not be removed to the best advantage by means of scrapers. The eggs are attached, not to the cocoons, but to the bark of the trees, and certain eggs may be left in the attempt to remove the mass. An exten-

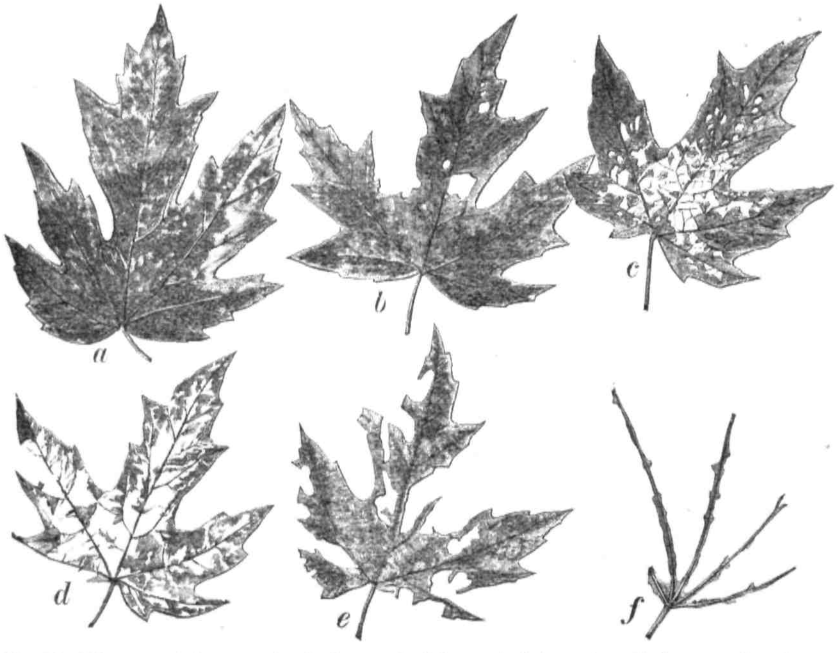

FIG. 89.—Silver maple leaves eaten by larvæ of white-marked tussock moth in successive stages of growth from *a* (newly hatched larvæ) to *f* (full-grown larvæ)—reduced (original).

sive series of experiments has therefore been carried on, with a view to securing a liquid which will penetrate and destroy the egg masses.

A satisfactory liquid for this purpose has been found in creosote oil, to which turpentine is added to keep it liquid in cold weather, with tar to blacken it so that treated egg masses can be recognized at a glance. The workman is furnished with a pole, to the end of which a small sponge is tied. He goes from tree to tree, dipping the sponge occasionally into the creosote preparation and touching with it each egg mass found. This is a simple and very rapid method. It has the advantage of rapidity over the scraping method described above, since after the eggs are scraped off they must be collected and carried away for burning.

A modification of this plan may be used to advantage against the tussock moth. The pure white color of the egg mass of the tussock moth, however, renders the use of coal tar in the preparation unnecessary, since the creosote oil alone will discolor it enough to render a treated mass recognizable at a distance.

No explicit directions for spraying with arsenical poisons against this insect are needed. The same liquid and the same apparatus that are used against the elm leaf-beetle may be used against this insect, and the spraying may be done at about the same time of the year. It is essential that the caterpillars of the first generation shall be killed, as the second and more destructive brood will thus be prevented.

Banding of the trees is practiced to advantage with this species. It is the only one of the shade-tree insects, except the bagworm, which has a wingless female. All the others, except the gypsy moth, spread from tree to tree by the flight of the female. Many experiments have been made with different styles of bands, and it has been practically proved that a broad, thick strip of raw cotton, tied about the trunk of the tree with a string, is after all the most efficacious and perhaps the cheapest. Such bands have to be renewed occasionally, as they become more or less matted together and spoiled by rainstorms.

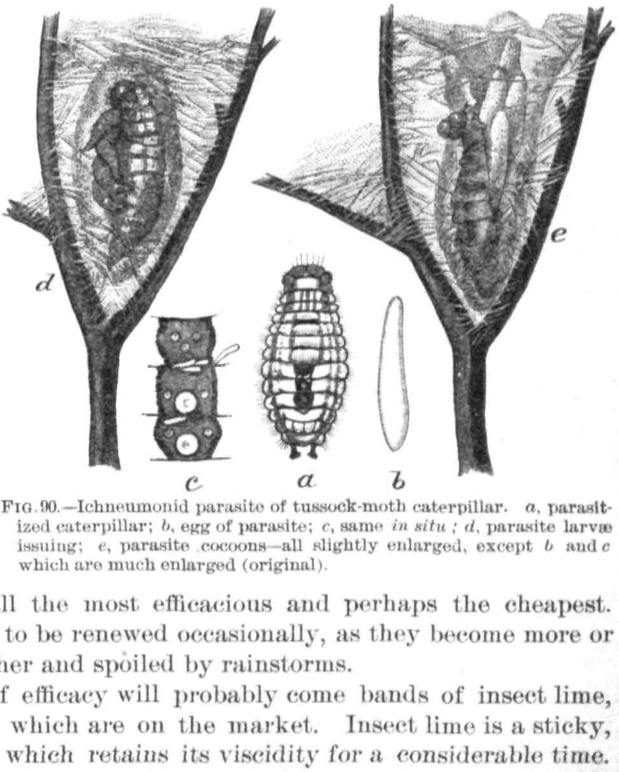

FIG. 90.—Ichneumonid parasite of tussock-moth caterpillar. *a*, parasitized caterpillar; *b*, egg of parasite; *c*, same *in situ*; *d*, parasite larvæ issuing; *e*, parasite cocoons—all slightly enlarged, except *b* and *c* which are much enlarged (original).

Next in point of efficacy will probably come bands of insect lime, several brands of which are on the market. Insect lime is a sticky, coal-tar product, which retains its viscidity for a considerable time. A ring made around a tree will remain operative for some weeks in warm weather.

THE FALL WEBWORM.

(*Hyphantria cunea* Drury; figs. 91 to 93.)

Associated with the white-marked tussock moth in its damage to the shade trees of the city of Washington during the summer of 1895, were very many specimens of the fall webworm; in fact, this insect

was more abundant during the summer of 1895 than it has been in Washington since 1886. It was not as numerous and destructive as the white-marked tussock moth, and the last generation was so extensively parasitized as to lead to the anticipation that the species will not be especially abundant during 1896.

The fall webworm is a typical American species. It is found from Canada to Georgia and from Montana to Texas. It is an almost universal feeder, and the records of the Division of Entomology list about 120 species of shade and ornamental trees, as well as fruit trees, upon the leaves of which it feeds.

In the District of Columbia and north to New York City there are two generations annually, as is the case with the tussock moth. In more northern localities, where it is single brooded, it loses its place as a species of great importance. It hibernates as a pupa within a cocoon attached to the trunk of its food plant, or to tree boxes, neighboring fences, or to rubbish and sticks or stones at the surface of the ground. The different stages of the insect are shown in figs. 91 to 93. The moth, which may be either pure white or white spotted with black, flies at night and deposits a cluster of 400 or 500 eggs, upon either the upper or the under surface of the leaf. The caterpillars feed gregariously, and each colony spins a web which may eventually include all the leaves of a good-sized limb. Reaching full growth, the caterpillars leave the web and crawl down the trunk of the tree to spin their cocoons. The caterpillars of the second generation begin to make their appearance in force in August.

Remedies.—On account of the fact that the adult female is an active flier, we can use against the fall webworm but two of the remedies suggested for use against the tussock-moth caterpillars, namely, spraying with arsenical poisons and the collection of the cocoons. The gregarious habit of the larvæ, however, suggests another remedy which is practical and very efficient if thoroughly carried out. This is the destruction of the webs and the contained larvæ, either by cutting off the twigs which carry them and burning immediately, or burning the webs without pruning. If this work be done properly and against the early summer generation, the pruning method is unnecessary and inadvisable. By the use of a proper torch the webs and the caterpillars which they contain can be burned off at nightfall without necessarily destroying the life of the twigs, and a second crop of leaves will be put out a little later, so that the tree does not remain disfigured for any length of time. A bundle of rags wired to the end of a pole and saturated with kerosene makes a good torch for the purpose; or a porous brick wired to a pole and saturated with kerosene answers the purpose even better. Private persons will find this remedy sufficient. City authorities should apply an arsenical spray. Collecting the cocoons in winter may be carried on simultaneously with the collection of the egg masses of the white-marked tussock moth, but this, as well as other community remedies, will be referred to at another place.

THE RELATIVE IMMUNITY FROM INSECTS OF DIFFERENT VARIETIES OF SHADE TREES.

As regards a number of the principal shade trees that are most commonly grown, there does not seem to be any great preference on the part of the fall webworm and the tussock-moth caterpillar. If a moth happens to lay her eggs upon or near a given tree standing in a row, the species will naturally spread along the row before it will cross to the opposite side. In this way erroneous ideas of the relative immunity of trees have frequently been gathered.

Taking the insect question as a whole, however, there is a decided difference in the relative value of certain varieties. In December, 1893, the Tree Planting and Fountain Society of Brooklyn asked a number of experts to name for the use of the society nine of the most valuable trees for planting in Brooklyn. Three of these trees were to be large-growing, three medium-sized, and three small-growing varieties.

The reply of Mr. B. E. Fernow, Chief of the Division of Forestry in the United States Department of Agriculture, was comprehensive and of great value. He tabulated nearly 50 varieties, analyzing their good qualities under the different heads of endurance, recuperative power, cleanliness, beauty of form, shade, leaf period, rapidity of growth, and persistence, giving 3 as the highest mark for any one of these qualities and estimating the value of a given tree by the total number of marks given to it. This reply was printed and issued as a circular by the Brooklyn society. Mr. Fernow made no specific rating for immunity from insect pests, although in his introductory remarks he seems to have included the insect question under the head of cleanliness.

As is quite to be expected, the rating arrived at from the summing up of the qualities mentioned differs very considerably from the rating which might be arrived at from the quality of immunity from insects. Taking the large and medium-sized trees only (36 species in all), Mr. Fernow's rating stands as follows, only the total gained by the addition of the ratings in the several qualities considered being given:

Variety of tree.	Total rating (Fernow).	Insect rating (Howard).
LARGE-SIZED TREES.		
Red oak (*Quercus rubra*)	22	2.5
Scarlet oak (*Quercus coccinea*)	22	2.5
Yellow oak (*Quercus velutina*)	22	2.5
American elm (*Ulmus americana*)	22	1.5
Sugar maple (*Acer saccharum*)	19	2.5
Black maple (*Acer nigrum*)	19	2.5
Tulip tree (*Liriodendron tulipifera*)	19	3.0
European linden (*Tilia vulgaris*)	19	1.5
Small-leafed linden (*Tilia microphylla*)	19	2.0
Sweet gum (*Liquidambar styraciflua*)	19	2.0
White oak (*Quercus alba*)	19	2.0
Bur oak (*Quercus macrocarpa*)	19	2.0
Oriental plane tree (*Platanus orientalis*)	19	1.5
Kentucky coffee tree (*Gymnocladus divisus*)	19	2.0
American plane tree (*Platanus occidentalis*)	18	1.5
Sycamore maple (*Acer pseudo-platanus*)	17	2.0
American linden (*Tilia americana*)	17	1.5

Variety of tree.	Total rating (Fernow).	Insect rating (Howard).
MEDIUM-SIZED TREES.		
Red maple (*Acer rubrum*)	22	2.0
Shingle oak (*Quercus imbricaria*)	21	2.0
Willow oak (*Quercus phellos*)	21	2.5
Slippery elm (*Ulmus pubescens*)	21	2.0
Norway maple (*Acer platanoides*)	20	2.0
Box elder (*Negundo negundo*)	20	.0
European elm (*Ulmus campestris*)	19	.5
Scotch elm (*Ulmus montana*)	19	1.0
Hackberry (*Celtis occidentalis*)	19	1.5
Silver-leafed maple (*Acer saccharinum*)	17	1.5
Tree of heaven (*Ailanthus glandulosa*)	16	2.5
Horse-chestnut (*Æsculus hippocastanum*)	16	2.0
Japanese sophora (*Sophora japonica*)	16	2.5
Hardy catalpa (*Catalpa speciosa*)	16	2.0
Gingko (*Gingko biloba*)	16	3.0
Honey locust (*Gleditschia triacanthos*)	15	1.0
Cottonwood (*Populus monilifera*)	15	.5
Balm of Gilead (*Populus balsamifera* v. *candicans*)	15	.5
Black locust (*Robinia pseudacacia*)	14	.5

The writer has made ratings of these same trees according to their immunity from the attacks of insects, the trees most immune being rated at 3 and those most attacked by insects at 0. The figures relating to insect attack are displayed above in a contrasted column next to the total rating, and in order that the relative importance from the insect standpoint may be seen at a glance the same trees have been rearranged in a separate table as follows:

Variety of tree.	Insect rating.	Variety of tree.	Insect rating.
Gingko (*Gingko biloba*)	3.0	Slippery elm (*Ulmus pubescens*)	2.0
Tulip tree (*Liriodendron tulipifera*)	3.0	Norway maple (*Acer platanoides*)	2.0
Sugar maple (*Acer saccharum*)	2.5	Hardy catalpa (*Catalpa speciosa*)	2.0
Red oak (*Quercus rubra*)	2.5	European linden (*Tilia vulgaris*)	1.5
Ailanthus (*Ailanthus glandulosa*)	2.5	American elm (*Ulmus americana*)	1.5
Scarlet oak (*Quercus coccinea*)	2.5	Hackberry (*Celtis occidentalis*)	1.5
Yellow oak (*Quercus velutina*)	2.5	Silver-leafed maple (*Acer saccharinum*)	1.5
Willow oak (*Quercus phellos*)	2.5	Oriental plane tree (*Platanus orientalis*)	1.5
Black maple (*Acer nigrum*)	2.5	American plane tree (*Platanus occidentalis*)	1.5
Japanese sophora (*Sophora japonica*)	2.5	American linden (*Tilia americana*)	1.5
Horse-chestnut (*Æsculus hippocastanum*)	2.0	Honey locust (*Gleditschia triacanthos*)	1.0
Red maple (*Acer rubrum*)	2.0	Scotch elm (*Ulmus montana*)	1.0
Small-leafed linden (*Tilia microphylla*)	2.0	Cottonwood (*Populus monilifera*)	.5
White oak (*Quercus alba*)	2.0	Balm of Gilead (*Populus balsamifera* v. *candicans*)	.5
Sweet gum (*Liquidambar styraciflua*)	2.0	European elm (*Ulmus campestris*)	.5
Bur oak (*Quercus macrocarpa*)	2.0	Black locust (*Robinia pseudacacia*)	.5
Kentucky coffee tree (*Gymnocladus divisus*)	2.0	Box elder (*Negundo negundo*)	.0
Sycamore maple (*Acer pseudo-platanus*)	2.0		
Shingle oak (*Quercus imbricaria*)	2.0		

It will be noticed that the trees listed by Mr. Fernow which we find to be most immune are the gingko and the tulip tree. Outside of the grounds of the Department of Agriculture at Washington and Central Park, New York, few gingko trees are grown in this country, except as occasional isolated examples. The tree itself is a very beautiful one, and singularly free from insect attack. In the long double row of these trees, now nearly twenty-five years old, on the grounds of the Department of Agriculture, but one species of injurious insect has ever been found, and the work of this species is very insignificant. It is the little sulphur-yellow leaf-roller, *Tortrix sulphureana*.

The tulip tree, which is given the same rating, is, for practical purposes, almost as exempt as the gingko. Of late years in the District of Columbia it has been rather extensively infested by a plant louse (*Siphonophora liriodendri*), but although the lice occur on the leaves in great numbers, the general appearance of the trees has not suffered. There is a little gall midge which produces little black spots on the tulip tree leaves and disfigures them to some extent, and quite recently Mr. Schwarz has found that tulip scrub is affected to some extent in the District of Columbia by a little bark-boring beetle.

The box elder is a singularly unfortunate choice for a shade tree in this climate. It is almost defoliated by the webworm, it is sought after by the tussock moth, and various leaf-rollers attack it as well as certain destructive borers. In the West the box elder plant bug (*Leptocoris trivittatus*) breeds upon it in enormous numbers, and not only damages the trees to a serious extent, but causes much further annoyance by entering houses for hibernation.

The European elm is given a low rank, almost entirely on account of its annual defoliation by the imported elm leaf-beetle.

The honey locust and the black locust, while not defoliated to the same extent as many other trees by the webworm and the tussock-moth caterpillar, are rendered very unsightly almost every year by the work of a leaf-mining Hispid beetle and of certain Lepidopterous leaf miners. They are also frequently killed by the large Lepidopterous borer, *Xyleutes robiniæ*, and certain Coleopterous borers also infest them.

From the insect standpoint, there are several fine-growing ornamental trees on the grounds of the Department of Agriculture, not listed above, which are seldom attacked by insects. The beeches, hornbeams, alders, and magnolias have very few insect enemies, and are rarely defoliated by either of the principal leaf-eating caterpillars.

With regard to the extreme attractiveness which the European elm possesses for the imported elm leaf-beetle, the question is frequently asked whether it would not be better to cut down all European elms growing in parks or in rows with American elms. Such a course,

however, would seem to be undesirable. After the elm leaf-beetle has established itself in a given locality, it will attack the American elms to a very serious extent, in the absence of its favorite food plant. It is, therefore, better to allow a few European elms to remain. These will then act as trap trees, and the necessity for treating a large number of trees will in most cases be greatly reduced.

In selecting shade trees, particularly for small cities and towns in agricultural regions, and even to a considerable extent in large cities, the relative honey-producing qualities of the proposed shade trees is a matter of some little importance; not so much, perhaps, in the matter of actual food for the ordinary honeybee as in that of the increase of bees on account of their great value as cross fertilizers of orchard trees and forage crops. From this point of view, there are five very important honey producers among the principal shade trees. These are, in order of importance: American linden, tulip tree, black locust, horse-chestnut, and sugar maple.

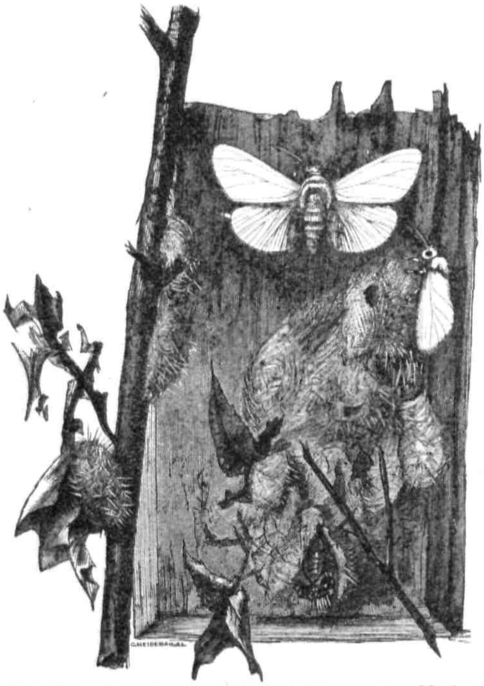

FIG. 91.—Fall webworm (*Hyphantria cunea*). Moths and cocoons—natural size (original).

GENERAL WORK AGAINST SHADE-TREE INSECTS IN CITIES AND TOWNS.

The question of proper work against the insects which affect shade trees in cities and towns, naturally divides itself under two heads: (1) What can be efficiently and economically done by city governments? (2) If city or town administrators will not appropriate a small amount of money to carry on work of this kind, what can citizens who are interested in the preservation of shade trees do?

The planting of shade trees seems to be considered a legitimate function of the board of public works in every municipality. It is sometimes done by a specially appointed officer, under the control of the superintendent of streets and sewers; or it is placed in charge of a subcommittee of the board, or a special commission of outsiders is appointed to superintend the work. Admitting that the planting of shade trees is a public matter, their care should also be a public duty. Yet

in not one of the larger or smaller cities of the Eastern United States with which the writer is familiar is any proper amount of work done by the public authorities against shade-tree insects. New York is the only city in the country where a man of entomological knowledge is employed to direct operations against shade-tree insects, either in the streets or the public parks. The writer does not wish to be understood as advocating the appointment of a paid entomologist by every city government, although where the parks are large in cities situated within the region of greatest shade-tree insect activity, such a course is always desirable. With an intelligent and industrious superintendent of parks, or a city forester, or whatever he may be termed, and the wise expenditure of a comparatively small amount of money each year, the shade trees of any city could be kept green throughout the summer.

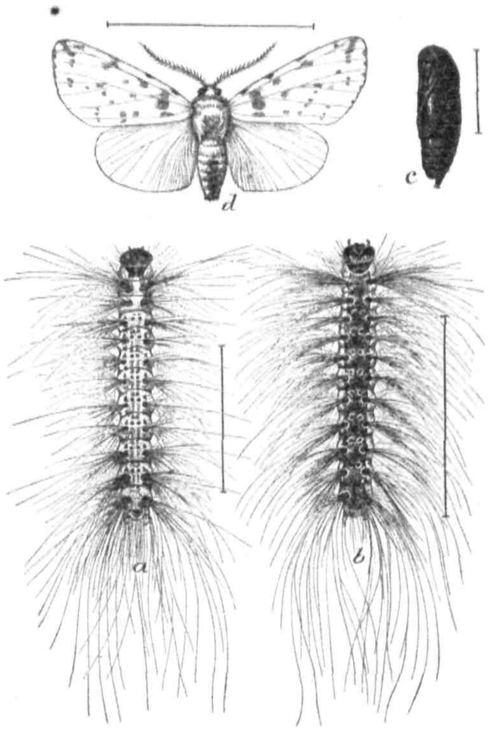

FIG. 92.—Fall webworm. *a*, light form of full-grown larva; *b*, dark form of same; *c*, pupa; *d*, spotted form of moth (compare fig. 91)—all slightly enlarged (original).

The amount of money to be expended in this direction would naturally vary with the number of trees to be attended to, as well as with the variety and the size of the trees and the geographical location of the city. Even in Brooklyn, however (and this seems to the casual observer to be the most unfortunate of all our Eastern cities from this standpoint), it is within bounds to estimate that the expenditure of $4,000 to $5,000 a year would result in green shade trees the summer through. This amount, moreover, will in all probability not need to be an annual appropriation. The first cost of a proper spraying apparatus will have to be added, but the apparatus once purchased and thorough work performed for two or three years consecutively, the probabilities are strong that the number of shade-tree insects would be reduced to such an extent that a considerably smaller annual expenditure would be sufficient.

The question of proper spraying apparatus is a rather serious one, since in this direction a considerable amount of money should be

expended. A steam apparatus will do the work with much greater rapidity than a hand pump, and yet with a strong double-acting force pump, which can be operated by a single man, and a tank of 100 gallons capacity, mounted upon a strong cart, many large trees can be well sprayed in the course of a day. From such a pump two lines of hose may be run with advantage. The working force of such an apparatus should be a horse to draw the cart, a man to drive and do the pumping, and one man to each line of hose. Several such machines have been used with good results in the work of the Gypsy Moth Commission, both for street trees and in the public parks. A steam apparatus, however, of such a capacity that a pressure of 75 pounds per square inch may be gained will enable the operation of four or five lines of hose simultaneously. The rapidity of work will

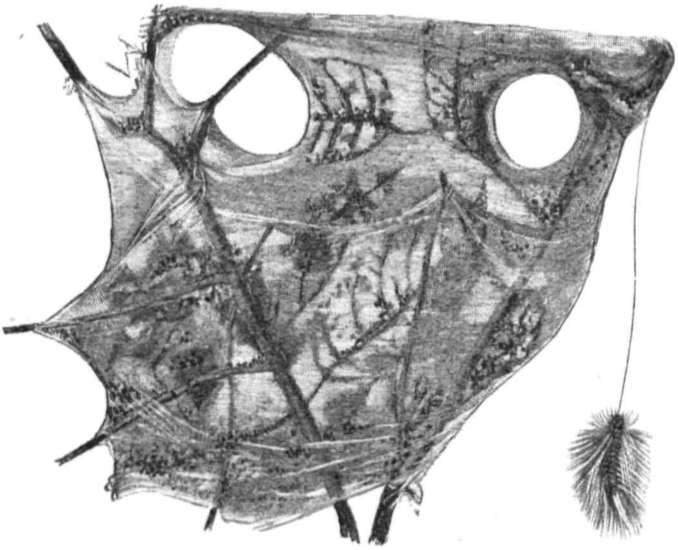

FIG. 93. Fall webworm. Suspended larva and section of web—natural size (original).

therefore be doubled, and certainly by the use of two such pumps the shade trees of any ordinary city can be gone over with sufficient rapidity to destroy all insects within the required time. A boiler mounted on a truck, the boiler to be complete with all fixtures, smokestack, bonnet, firing tools, springs to the truck, and a pump having a capacity of 10 to 20 gallons a minute connected with the boiler ready for operation, can be purchased for a sum well within $500. This truck should be mounted on wheels with broad tires, for running over sandy roads. Connecting this apparatus with a proper tank cart would be an additional expense, not to exceed $100 for a tank of a capacity of 200 gallons. Such an apparatus, furnished with hose and smoothbore nozzles of about one-sixteenth inch in diameter, when discharging under 40 pounds pressure from each of several

such nozzles, would spray about half a gallon of insecticide mixture per nozzle per minute.

A strong steam pump, to be used in connection with a small oil-burning boiler, the whole apparatus on a smaller scale than that described above, has been estimated at $275 by a prominent New York firm, delivered on board the cars.

There is no reason why an old steam fire engine could not be readily arranged for this shade-tree spraying work. In one or two instances a steam fire engine has been used for this purpose without modification, the object being simply to knock the insects from the trees by means of a strong stream of water. By such means as this the superintendent of the Military Academy kept the elm trees green at West Point several years ago. In every large city, where the fire department is necessarily kept in the best condition, an engine is occasionally retired. The transfer of such a retired engine to the street department could no doubt be readily made, and a little work by a competent steam fitter could transform it into a most admirable insecticide machine. In this way the initial expenditure for machinery would be avoided.

When the spraying apparatus has once been provided, the funds necessary for the purchase of insecticides and the necessary labor at the proper time must be available. If the work is not done promptly and at just the right time, more or less damage will result, and a greater expenditure will be necessary. During the latter part of May and the first part of June, in the case of nearly all prominent shade-tree insects, one or two thorough sprayings must be made. In fact, a second spraying, begun immediately after the completion of the first one, will in ordinary cases be as much as need be expected. In addition to this spraying work, a force of men must be employed for a time in July to destroy the elm leaf-beetle larvæ as they are descending to the ground and to burn the webs of the first generation of the fall webworm. This will finish the summer work. The winter work will consist of the destruction of the eggs of the white-marked tussock moth, the cocoons of the fall webworm, and the bags of the bagworm. The number of men to be employed and the time occupied will depend upon the exigencies of the case. Upon the thoroughness of this work will depend, to a large extent, the necessity for a greater or less amount of the summer work just described.

We have now to consider what can be done by citizens where city governments will not interest themselves in the matter. It is unreasonable to expect that a private individual will invest in a spraying apparatus and spray the large shade trees in front of his grounds. Therefore, in spraying operations where large trees exist in numbers there must be combination of resources. This affords an opportunity for the newly invented business of spraying at so much per tree. A resident of Bridgeport, Conn., who was formerly, and is yet for the

greater part of the year, a roofer and paver, has constructed several cart sprayers, and during the months of June and July (at a time, by the way, when the men in his employ are apt to be out of work) he sprays trees on the grounds of private individuals and along the streets in front of their grounds, under contract, at so much per tree, guaranteeing to keep the trees in fair condition during the season. His work has been directed solely against the elm leaf-beetle, since that is the only insect of great importance in Bridgeport. In the month of July last the writer, in driving through the streets of Bridgeport, found it easy to pick out the trees which had been treated in this way. Such elms were green, while all others were brown and nearly leafless. The defect of this plan as a general practice lies in the fact that not all property owners or residents can afford to employ a tree sprayer, while others are unwilling, since they deem it the business of the city authorities, or do not appreciate the value of tree shade.

Any effort, therefore, looking toward the arousing of popular sentiment or the banding together of the citizens in the interests of good shade is desirable. A most excellent plan was urged by one of the Washington newspapers the past summer. It advocated a tree-protection league, and each issue of the paper through the summer months contained a coupon which recited briefly the desirability of protecting shade trees against the ravages of insects, and enrolled the signer as a member of the league, pledging him to do his best to destroy the injurious insects upon the city shade trees immediately adjoining his residence. This is only one of several ways which might be devised to arouse general interest. The average city householder seldom has more than a half dozen street shade trees in front of his grounds, and it would be a matter of comparatively little expense and trouble for any family to keep these trees in fair condition. It needs only a little intelligent work at the proper time. It means the burning of the webs of the fall webworm in May and June; it means the destruction of the larvæ of the elm leaf-beetle about the bases of elm trees in late June and July; it means the picking off and destruction of the eggs of the tussock moth and the bags of the bagworm in winter, and equally simple operations for other insects should they become especially injurious. What a man will do for the shade and ornamental trees in his own garden he should be willing to do for the shade trees 10 feet in front of his fence.

THE PRINCIPAL INSECT ENEMIES OF THE GRAPE.

By C. L. Marlatt, M. S.,
First Assistant Entomologist, U. S. Department of Agriculture.

That the grape is distinctively an American plant is indicated by the fact that our indigenous wild species number nearly as many as occur in all the world besides. It is not to be wondered at, therefore, that this continent is responsible also for the chief enemies of the vine, both insect and fungous, as, for example, the grape phylloxera, which, in capacity for harm, taken the world over, outranks all other vine evils together, and such blighting fungous diseases as the two mildews and the black rot. The rapid growth of the vine industry in this country and the increasing cultivation of the less vigorous European grapes make it desirable to consider briefly, from the standpoint of remedies, its leading insect enemies.

Upward of 200 different insects have already been listed as occurring on the vine in this country, and the records of the Department alone refer to over 100 different insects. Few of these, however, are very serious enemies, being either of rare occurrence or seldom numerous, and for practical purposes the few species considered below include those of real importance. They are the grape phylloxera, the grapevine fidia, both chiefly destructive to the roots; the cane-borer, destructive particularly to the young shoots; the leaf-hopper, the flea-beetle, rose-chafer with its allies, and leaf-folder, together with hawk moths and cutworms, damaging foliage, and the grape-berry moth, the principal fruit pest.

The extent of the loss that frequently results from these insects may be understood by reference to a few instances. The phylloxera when at its worst had destroyed in France some 2,500,000 acres of vineyards, representing an annual loss in wine products of the value of $150,000,000, and the French Government had expended up to 1895 in phylloxera work over $4,500,000 and remitted taxes to the amount of $3,000,000 more. The grapevine fidia, on the authority of an Ohio correspondent, in a single season in one vineyard killed 400 out of 500 strong 5-year-old vines. The prominent leaf defoliators, as the rose-chafer and flea-beetle, frequently destroy or vastly injure the crop over large districts, and the little leaf-hopper, though rarely preventing a partial crop, is so uniformly present and widely distributed as to probably levy a heavier tribute on the grape in this country than any other insect.

These insects are, however, all amenable to successful treatment, and the loss may be very considerably limited if the proper methods of control are followed out. There are no remedies which apply generally to grape insects except the highly important considerations of clean culture and particularly the prompt collection and burning of prunings and leaves in the fall. The latter will very materially check most of the leaf insects and the cane-borer. Other remedies are particularized under each species.

THE GRAPEVINE PHYLLOXERA.

(*Phylloxera vastatrix* Planch.)

This insect has always existed on our wild vines, yet it was not until it had been introduced abroad and began to ravage the vine-

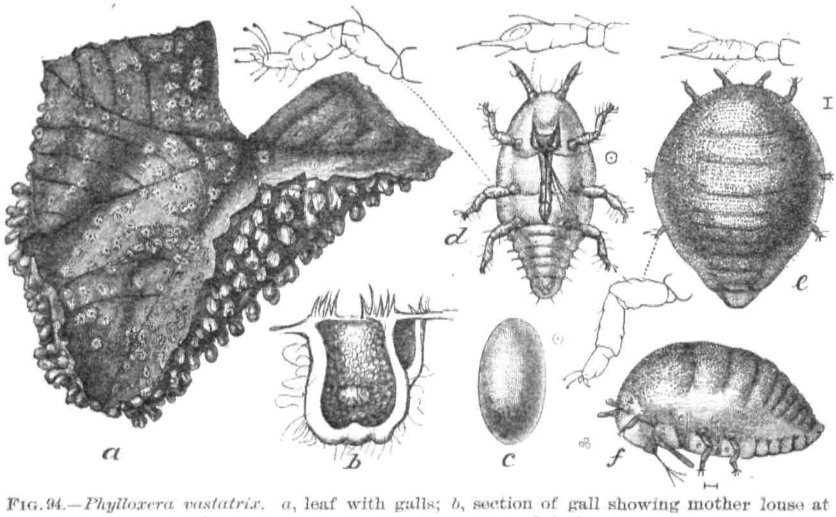

FIG. 94.—*Phylloxera vastatrix*. *a*, leaf with galls; *b*, section of gall showing mother louse at center with young clustered about; *c*, egg; *d*, larva; *e*, adult female; *f*, same from side—*a* natural size, rest much enlarged (original).

yards of the Old World that particular attention was drawn to it as a vine pest, or that anything definite was known of its habits. It appears in two destructive forms on the vine, the one forming little irregular spherical galls projecting from the underside of the leaves and the other subsisting on the roots and causing analogous enlargements or swellings. The leaf form is the noticeable one and is very common on our wild and cultivated vines. The root form is rarely seen, but is the cause of the real injury done by this insect to the vine, and while hidden and usually unrecognized, its work is so disastrous to varieties especially liable to attack that death in a few years is almost sure to result. It first produces enlargements or little galls on the rootlets. As it extends to the larger roots these

become swollen and broken, and finally the outer portion decomposes and rots, and the roots ultimately die. With the multiplication of the root lice and their extension to all parts of the root system, the vine stops growing, the leaves become sickly and yellowish, and in the last stages the phylloxera disappears altogether from the decomposed and rotting roots, and the cause of death is obscure to one not familiar with the insect. Many cases of death ascribed to drought, overbearing, winterkilling, etc., are undoubtedly due to the presence of the root louse.

The abundance of galls on the leaves is not an indication of the presence of the root louse in any numbers, but, in fact, the reverse of this is usually true; while on the other hand the destructive abundance of the lice on the roots is often, if not usually, accompanied by little, if any, appearance of the leaf form. This is particularly noticeable with the European grapes, which are very susceptible to phylloxera and rapidly succumb to it, yet rarely show leaf galls. American grapes, on the contrary, are generally very resistant to the root form, and yet are especially subject to the leaf-gall insect. Certain varieties, as the Clinton, which are most resistant to the former, are especially subject to the latter.

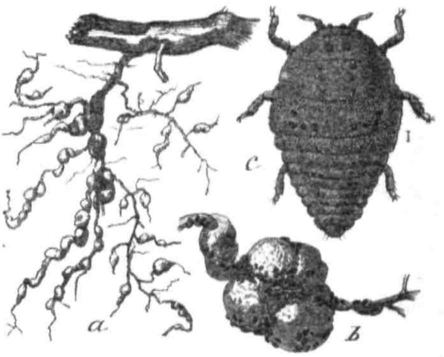

FIG. 95.—*Phylloxera vastatrix.* *a*, root galls; *b*, enlargement of same showing disposition of lice; *c*, root gall louse—much enlarged (original).

Distribution.—The phylloxera was carried to France about 1859, on rooted American vines, and has since spread through the principal vine districts of southern Europe, extending also into Algeria and through southern Russia into the adjoining countries of Asia. It has also been carried to New Zealand and south Africa. In this country it was at first known only in the region east of the Rocky Mountains, but was soon after found in California, where, however, it is confined practically to the vine districts of the Napa and Sonoma valleys.

Life history and habits.—The life cycle of the phylloxera is a complicated one. It occurs in four forms in the following order: The leaf-gall form (*gallicola*), the root or destructive form (*radicicola*), the winged or colonizing form, and the sexual form. The leaf-gall insect produces from 500 to 600 eggs for each individual, the root-inhabiting insect not much above 100 eggs, the winged insect from 3 to 8, and the last or sexed insect but 1 egg. This last is the winter egg and may be taken as a starting point of the life cycle. It is laid in the fall on old wood, and hatches, the spring following, into a louse,

which goes at once to a young leaf, in the upper surface of which it plants its beak. The sucking and irritation soon cause a depression to form about the young louse, which grows into a gall projecting on the lower side of the leaf. In about fifteen days the louse becomes a plump, orange-yellow, full-grown, wingless female, and fills its gall with small yellow eggs, dying soon after. The eggs hatch in about eight days into young females again, like the parent, and migrate to all parts of the vine to form new galls. Six or seven generations of these wingless females follow one another throughout the summer, frequently completely studding the leaves with galls. With the approach of cold weather the young pass down the vines to the roots, where they remain dormant until spring. The root is then attacked and a series of subterranean generations of wingless females is developed. The root form differs but slightly from the inhabitant of the leaf galls, and the swellings or excrescences on the roots are analogous to those on the leaves.

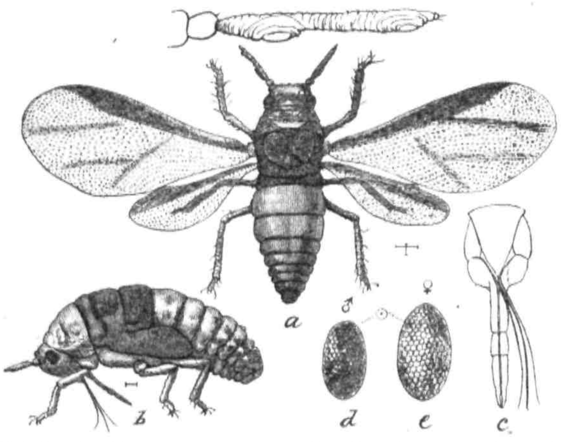

FIG. 96.—*Phylloxera vastatrix*. *a*, migrating stage, winged adult; *b*, pupa of same lateral view; *c*, mouth-parts with thread-like sucking setæ removed from sheath; *d* and *e*, eggs showing characteristic sculpturing—all enlarged (original).

During late summer and fall of the second year some of the root lice give rise to winged females which escape through cracks in the soil on warm bright days and fly to neighboring vines. These winged lice lay their eggs within a day or two in groups of two or four in cracks in the bark or beneath loose bark on the old wood of the vine and die soon after. The eggs are of two sizes, the smaller and fewer in number yielding males in nine or ten days, and the larger the females of the only sexed generation developed in the whole life round of the insect. In this last and sexed stage the mouth-parts of both sexes are rudimentary, and no food at all is taken. The insect is very minute and resembles the newly hatched louse of either the gall or the root form. The single egg of the larva-like female after fertilization rapidly increases in size until it fills the entire body of the mother and is laid within three or four days, bringing us back to the winter egg or starting point.

This two-year life round is not necessary to the existence of the species, and the root form may and usually does go on in successive

broods year after year, as in the case with European vines, on the leaves of which galls rarely occur. Under exceptional circumstances all of the different stages may be passed through in a single year. The young from leaf galls may also be easily colonized on the roots, and it is probable that the passage of the young from the leaves to the roots may take place at any time during the summer. The reverse of this process, or the migration of the young directly from the roots to the leaves, has never been observed.

The complicated details noted above were only obtained after years of painstaking research, conducted by the late Professor Riley in this country and many careful investigators in France.

Means of dispersion.—The distribution of phylloxera is, first, by means of the winged females; second, by the escape, usually in late summer, of the young root lice through cracks in the soil and their migration to neighboring plants; third, by the carrying of the young leaf-gall lice by winds or other agencies, such as birds or insects, to distant plants; fourth, by the shipping of infested rooted plants or cuttings with winter eggs. By the last means the phylloxera has gained a world-wide distribution; the others account for local increase.

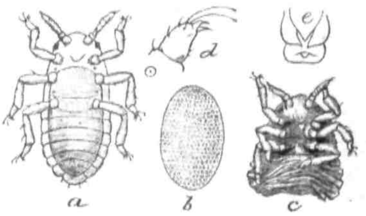

FIG. 97.—*Phylloxera vastatrix.* *a*, sexed stage-larviform female, the dark-colored area indicating the single egg; *b*, egg, showing the indistinct hexagonal sculpturing; *c*, shriveled female after oviposition; *d*, foot of same; *e*, rudimentary and functionless mouth-parts (original).

REMEDIES AND PREVENTIVES.

The enormous loss occasioned by this insect when it reached the wine districts of the Old World led to the most strenuous efforts to discover methods of control. Of the hundreds of measures devised few have been at all satisfactory in results. The more important ones are the use of bisulphide of carbon and submersion to destroy the root lice; and, as preventive measures, the use of resistant American stocks on which to graft varieties subject to phylloxera and the planting of vineyards in soil of almost pure sand.

Bisulphide of carbon.—The use of this liquid insecticide is practicable only in soils of such consistency as to hold the vapor until it acts on the root lice and yet friable enough to afford it enough penetration. It will not answer in compact clay soils, in very light sandy ones, or in soils liable to crack excessively. The liquid is commonly introduced into the soil by hand injectors at any season except that of blooming or of ripening of the fruit. Sometimes sulphuring plows are used, or the liquid is mixed with water and the soil about the vines thoroughly drenched. The great volatility of the bisulphide enables it to penetrate to the minutest roots, and the lice quickly perish. Four or five injections of one-fourth ounce each may be made to the

square yard over the entire surface of the vineyard, inserting the implement from 8 to 12 inches and not approaching within 1 foot of the base of the vine. The opening in the soil must be promptly closed with the foot. A large number of small doses is preferable to a few large ones. This treatment will ordinarily have to be repeated every year or two, and is therefore expensive and unsatisfactory and not to be recommended except where other means are not available.

Submersion.—Next to the use of resistant stocks, by far the best means against the phylloxera is in inundating vineyards at certain seasons of the year and for definite periods, being applicable wherever irrigation is practiced or water may be applied without too great expense. Submerging as a means against insects is a very ancient practice in southern Russia and in Greece, but was first used against phylloxera in 1868, in France, and is now practiced wherever feasible. The best results are obtained in soils which water will penetrate rather slowly. In loose and sandy soils submersion is impracticable. For this treatment vineyards are commonly divided into rectangular plats by embankments of earth, the latter protected from erosion by planting to some forage crop. As now practiced, the vines are inundated shortly after the fruit is gathered, when growth of the vines has ceased, but the phylloxera is still in full activity and much more readily destroyed than during the dormant winter season. The earlier the application the shorter the period required. During September from eight to fifteen days will suffice, and in October eighteen to twenty days, while if delayed until November a period of forty to sixty days will be needed. Copious irrigation at any time during the summer, if it can be continued for forty-eight hours, will give very considerable relief from phylloxera.

Planting in sand.—It was early observed that vines in very sandy soil were little subject to phylloxera injury, probably owing to the fact that the sand does not crack and allow the insects to escape and spread, being more thoroughly wetted with rains and subterranean moisture, and the insect is drowned out, as in submergence. The resistance is proportionate to the percentage of sand in the soil. In France vineyards are very successfully established on the sandy shores of the Mediterranean and in the alluvial sands of the valley of the Rhone and other streams.

American stocks.—The use of American vines, either direct for the production of fruit or as stocks on which to graft susceptible European and American varieties, has practically supplanted all other measures against phylloxera in most of the infested vineyards of the world. The immunity to root attack of American vines seems to be due to the thicker and denser bark covering of the roots and to greater natural vigor. All our vines are not equally resistant, and no vines are wholly immune, while several of our cultivated varieties,

as the Delaware, are almost as defenseless as European vines. Of the many wild American vines, those of chief importance as sources of stocks are the Æstivalis, Riparia, and Labrusca. Of these, Æstivalis and its cultivated varieties rank first in resistant qualities. The varieties of this species commonly grown and used for stocks are Herbemont and Cunningham. These are also very valuable on account of the superior quality of their own fruit.

The wild varieties of Riparia are quite resistant to the root louse, although the most subject of all vines to the attacks of the leaf-gall lice. Of the cultivated varieties, the Clinton, Taylor, Solonis, etc., are very commonly used as stocks. The fox grapes, derived from *Vitis labrusca*, while more resistant than European grapes, are much inferior to the other American species mentioned in this respect. Isabella and Catawba, for example, are very subject to root lice; the Concord, while not often seriously injured, is still rather subject to attack and therefore not so valuable as a source of resistant stocks. There are many hybrids of these and other American species, which are used either direct for their fruit or as stocks. Conditions of climate and soil will determine the particular variety to be employed, and these points can only be settled by experimental tests for new localities.

THE GRAPEVINE FIDIA.

(*Fidia viticida* Walsh.)

During midsummer the leaves of grapes are frequently riddled with irregular holes by the attacks of a little beetle which, when disturbed, falls to the ground with its legs folded up against its body, feigning death or "playing possum." The beetle is about a quarter of an inch long, rather robust, and of a brown color, somewhat whitened by a dense covering of yellowish-white hairs. In the nature and amount of the injury it does at this stage it resembles the rose-chafer, for which it is sometimes mistaken. Following the injury to the foliage, the vines may be expected, if the beetles have been abundant, to present a sickly appearance, with checking of growth and ultimate death, due to the feeding on the roots of the larvæ, for, as in the case of the phylloxera, the root injury is much more serious than the injury to foliage. Vines sometimes die after having developed half their leaves, or may survive until the fruit is nearly mature.

This insect occurs very generally in the Mississippi Valley States, from Dakota to Texas, and more rarely east of the Alleghanies and southward to Florida. The beetle has caused serious damage to foliage, notably in Missouri, Illinois, and Ohio, having been recognized over thirty years ago in the first-mentioned State as one of the worst enemies of the grape. The work of the larvæ has been recognized only recently by Mr. Webster and others in northern Ohio, but it may be looked for wherever the beetle occurs.

Life history.—The life history as worked out by Mr. Webster is briefly as follows: The yellowish eggs in large batches are thrust in cracks of the bark of the old wood, usually well above ground, as many as 700 having been counted on a single vine. Very rarely are they placed in cracks in the soil about the base of the vine, but so loosely are they attached to the bark that they not infrequently fall to the ground. The larvæ, on hatching, fall clumsily to the ground, and quickly disappear in cracks in the soil, chiefly near or just at the base of the vine. They feed at first on the fibrous roots near the point of entrance, but soon reach the larger roots, and completely denude them of bark, gradually extending outward through the soil

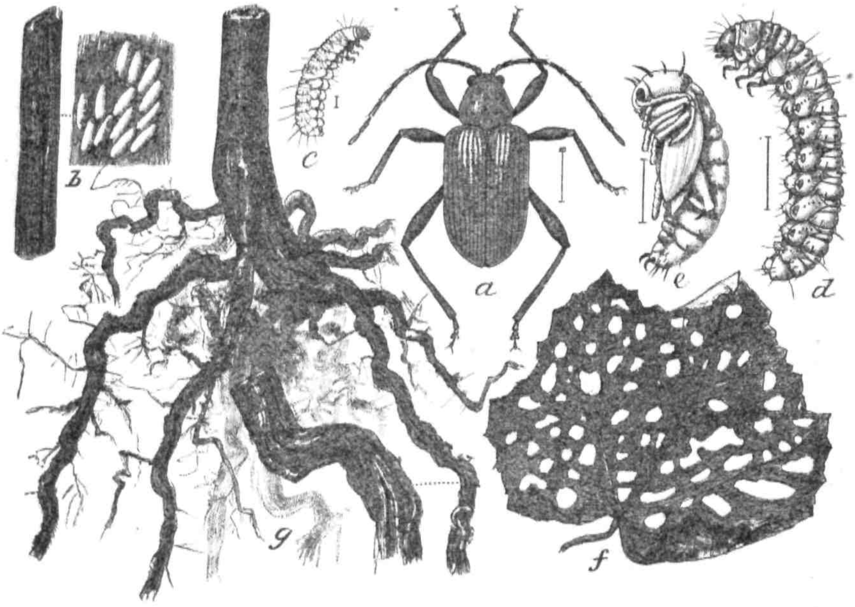

FIG. 98.—*Fidia viticida.* *a*, beetle; *b*, eggs represented natural size under fold of bark and much enlarged at side; *c*, young larva; *d*, full-grown larva; *e*, pupa; *f*, injuryto leaf by beetles; *g*, injury to roots by larvæ—*b* (in part) and *f* and *g* natural size, rest much enlarged (original).

to a distance of at least 3 feet, and downward to a depth of at least 1 foot. Most of them reach full growth by the middle of August, attaining a length of nearly half an inch, and construct little cavities or earthen cells in the soil, in which they hibernate until June of the following year, when they change to pupæ.

The beetles emerge about two weeks after pupation, and begin to feed from the upper surface of the leaves. With thin-leafed grapes they eat the entire substance of the leaf, but with thick-leafed varieties the downy lower surface is left, giving the foliage a ragged, skeletonized look. They feed on any cultivated grape, also on the wild grapes, which have probably been their food from time immemorial.

Most of the adults disappear by the first of August, a few scattering individuals remaining until the first of September.

Remedies and preventives.—It is evident that if the beetle can be promptly exterminated the injury to the foliage will be limited, and the subsequent much greater damage by larvæ to the roots avoided. The first effort, therefore, should be to effect the killing of the beetles, which may be done by the use of an arsenical spray, with lime, applying it at the customary strength of 1 pound to 150 gallons of water. The feeding of the beetles on the upper surface of the leaves makes them especially easy to control by this means. If this be deferred until it is unsafe to apply an arsenical to the vines, the beetles may be collected and destroyed in the manner recommended for the rose-chafer. The larvæ may be destroyed about the roots by injections of bisulphide of carbon made in the way already described for the phylloxera. A safer remedy, and a very effective one if applied before the end of June or before the larvæ have scattered, is to wet the soil about the vines with a solution of kerosene emulsion. The emulsion should be diluted nine times, and a gallon or two of the mixture poured in a basin excavated about the base of the vine, washing it down to greater depths an hour afterwards with a copious watering.

THE GRAPE CANE-BORER.

(*Amphicerus bicaudatus* Say.)

The young shoots of the grape during the spring months in some districts will often be observed to suddenly break off or droop and die, and if examination be made a small hole will be found just above the base of the withered shoot, with a burrow leading from it a short distance into the main stem. Within the burrow will be found the culprit in the form of a peculiar cylindrical brown beetle about half an inch long. This beetle has long been known as the apple twig-borer, from its habit of boring into the smaller branches of the apple in the manner described for the grape. It also sometimes similarly attacks pear, peach, plum, forest and shade trees, and ornamental shrubs. To the grape, however, it is especially destructive, and the name "grape cane-borer" is now given to it as more appropriate. Much complaint of this beetle is always received during the winter and early spring. Frequently all the new growth is killed, and in some cases vines have been entirely destroyed. It is extremely common in the States bordering the Mississippi, from Iowa to Arkansas, and also in Texas, often becoming throughout this region the most important insect enemy of the vine. It also occurs eastward to the coast, but rarely causes much damage in its eastern range.

It breeds in dying wood, such as large prunings, diseased canes, and also in dying or drying wood of most shade and fruit trees. It has been found by the writer breeding very abundantly in roots of uprooted maples and in diseased tamarisk stems. In old, dry wood it

will not breed, so far as is known, nor in vigorous live growth, but seems to need the dying and partially drying conditions mentioned. The insect has but one brood yearly. The beetles mature for the most part in fall, and generally remain in their larval burrows until the following spring. A few may leave the burrows in the fall and construct others in the twigs of apple or other plants in which to hibernate. In the spring, however, they begin their destructive work early, burrowing into the axils of the grape and occasionally also into other plants. This is undoubtedly partly for food, but seems largely

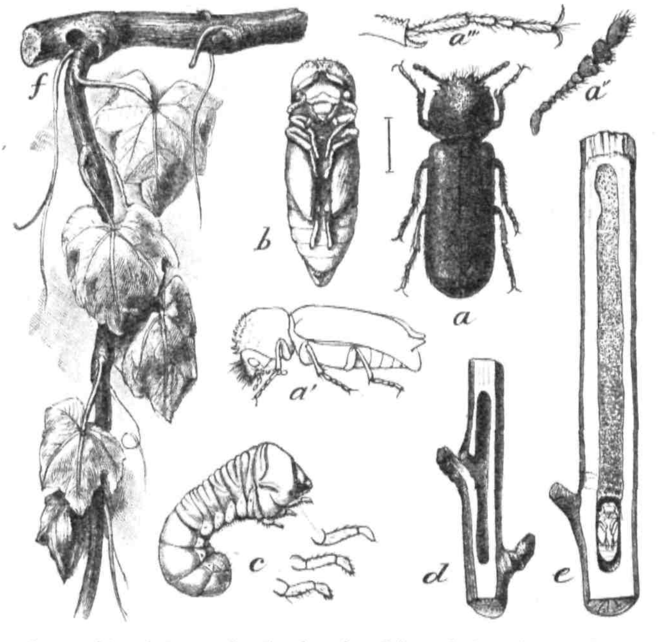

FIG. 99.—*Amphicerus bicaudatus.* *a*, beetle, dorsal and lateral view; *b*, pupa from beneath; *c*, larva from side, with enlargements of the thoracic feet; *d*, burrow in apple twig made by adult; *e*, larval gallery in tamarisk, with pupa in cell at end; *f*, injury to young shoot and cane, showing the entrance to burrow of beetle near *f* and the characteristic wilting of the new growth—all much enlarged except *d*, *e*, and *f* (original).

malicious, for it certainly has nothing to do with egg laying, although it may have some connection with the marital relation. The eggs are laid chiefly in May, or as early as March or April in its southern range, and the larvæ develop during summer, transforming to pupæ and beetles in the fall.

On the Pacific Coast a closely allied but somewhat larger species (*Amphicerus punctipennis* Lec.) breeds in grape canes and other plants, and probably has similar burrowing habits in the adult stage.

Remedies.—It will be apparent at once that to limit the work of this insect it will be necessary to promptly destroy all wood in which it will breed. This means the careful removal and burning of all dis-

eased wood and prunings at least by midsummer, thus destroying the material in which the larvæ are probably undergoing their development. If precautions of this sort are neglected and the beetle appears in the vineyard in spring, the only recourse is to cut out by hand every affected part and destroy the beetles. On warm days they may sometimes be collected in numbers while running about the vines.

THE GRAPEVINE FLEA-BEETLE.

(*Haltica chalybea* Ill.)

A little, robust, shining blue, or sometimes greenish, beetle, about one-fifth of an inch long, inclined to jump vigorously, and having greatly enlarged thighs, frequently appears on the vine in early spring, and bores into and scoops out the unopened buds, sometimes so completely as to kill the vine to the roots. It attacks also the newly expanded leaves, filling them with small, roundish holes, and later deposits its orange eggs in clusters on their lower surface. Little shining brown larvæ come from these, which also feed on the leaves, and, if abundant, leave little but the larger veins. The larvæ are present for about a month during May and June, when they disappear into the ground, and transform to beetles during the latter part of June and in July. This second brood of beetles remain on the leaves through the summer, feeding a little, but doing but little damage to the vines, now in full leaf. In the fall the beetles go into winter quarters in any protection, as in cracks in fences or buildings, in masses of leaves, under bark, etc.

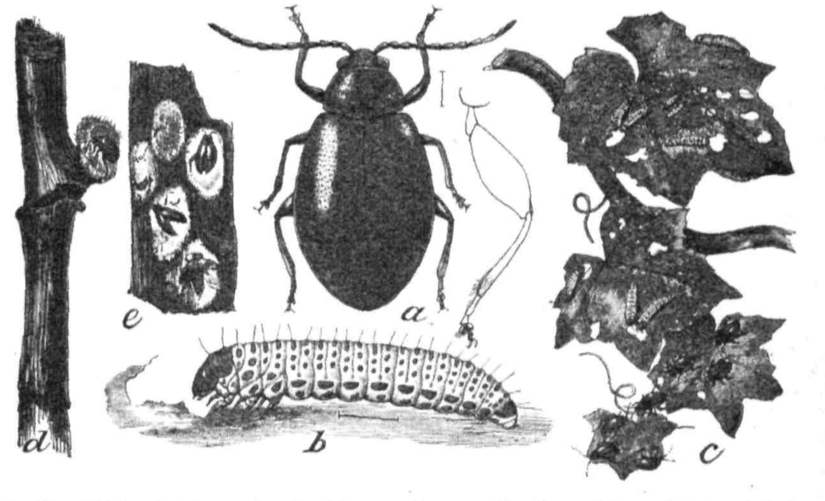

FIG. 100.—*Haltica chalybea*. *a*, beetle; *b*, larva; *c*, larvæ and beetles on foliage; *d*, injury to buds; *e*, beetles killed by fungus—*a* and *b* much enlarged, rest natural size (original).

The grapevine flea-beetle is sometimes erroneously called thrips. It occurs throughout the United States and Canada, the time of its appearance varying with the latitude, and possibly being double-brooded in the South. It is often abundant on wild vines, and also occurs on the alder. In the spring it is, perhaps, the subject of more frequent complaint than any other grape insect.

The damage to the buds is most to be feared and the hardest to prevent. A very strong arsenical wash, say, 1 pound to 50 gallons of water, with lime, applied before or as soon as the beetles appear, will, perhaps, afford protection. Mr. Howard has found also that the beetles at this season may be successfully jarred into cloth collecting frames placed about the vines as recommended for the rose-chafer, and that if the cloth is saturated with kerosene, the beetles striking it will soon perish. Later in the season the beetles and larvæ on the foliage may be reached by an arsenical spray of the customary strength, viz, 1 pound of the poison to 150 gallons of water.

THE ROSE-CHAFER.

(*Macrodactylus subspinosus* Fabr.)

With the blooming of the grape, an awkward, long-legged, light-brown beetle about one-third of an inch in length frequently appears in enormous swarms, at first devouring the blossoms, then the leaves, reducing them frequently to mere skeletons, and later attacking the young fruit. By the end of July these unwelcome visitors disappear as suddenly as they come.

Though now distinctively a grape pest, it was first known as an enemy of the rose, whence its name, "rose-bug," or rose-chafer. It attacks also the blossoms of all other fruit trees and of many ornamental trees and shrubs, and, in fact, in periods of great abundance, stops at nothing—garden vegetables, grasses, cereals, or any green thing. At such times plants appear a living mass of sprawling beetles clustering on every leaf, blossom, or fruit.

The rose-chafer occurs from Canada southward to Virginia and Tennessee, and westward to Colorado, but is particularly destructive in the eastern and central portions of its range, notably in New Jersey, Delaware, and to a less extent in New England and the Central States.

It passes its early stages in grass or meadow land, especially if sandy—the larvæ feeding on the roots of grasses a few inches below the surface of the ground like the common white grub, which they closely resemble except in size. The eggs are laid in the ground in June and July, and the larvæ become full grown by autumn and transform to pupæ the following spring, from two to four weeks prior to the emergence of the beetles.

Remedies.—The rose-chafer is a most difficult insect to control or destroy, and the enormous swarms in which it sometimes appears make the killing of a few thousand or even millions of little practical

value. Practically all substances applied to vines to render them obnoxious to the beetles have proved of little value, but a correspondent reports having successfully protected his vineyard last summer by spraying with a wash made by diluting 1 gallon of crude carbolic acid in 100 gallons of water. The arsenicals are available only when the beetles are not very numerous; otherwise their ranks are constantly recruited by newcomers, and under these circumstances all insecticides, however effective ordinarily, are unavailable. When this is the case, the only hope is in collecting the beetles or in covering and protecting plants with netting, or later in bagging grapes. Advantage may be taken of their great fondness for the bloom of spiræa,

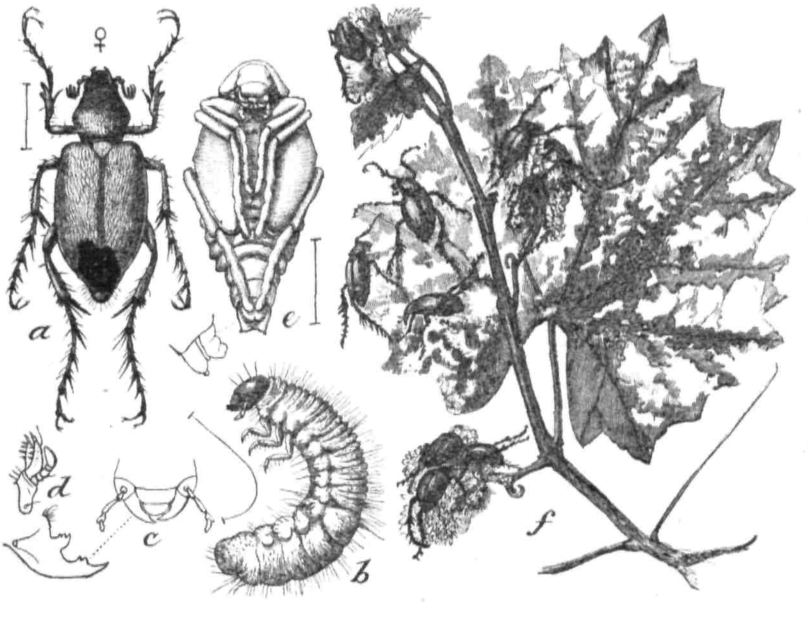

FIG. 161.—*Macrodactylus subspinosus*. *a*, beetle; *b*, larva; *c* and *d*, mouth-parts of same; *e*, pupa; *f*, injury to leaves and blossoms with beetles, natural size, at work (original).

and rows of these flowering shrubs may be planted about the vineyard to lure them and facilitate their collection.

They may be gathered from these trap plants, or the grapes themselves, in large hand beating nets, or by jarring into large funnel-shaped collectors on the plan of an inverted umbrella. The latter apparatus should have a vessel containing kerosene and water at the bottom to wet and kill the beetles.

All measures must be kept up unceasingly if any benefit is to be derived.

The numbers of the rose-chafers may be considerably limited by restricting the areas in which they may breed. All sandy meadow

land especially should be broken up and cultivated to annual crops, and the more general the cultivation of all lands the fewer will be the rose-chafers. In this procedure notable results may only be secured by the cooperation of a neighborhood.

THE GRAPE LEAF-FOLDER.

(*Desmia maculalis* Westw.)

One of the noticeable features of a vineyard, particularly in midsummer and later, is the many folded leaves the interiors of which have been skeletonized. This is especially evident with thick-leafed varieties, the whitish under surface contrasting strongly with the dark green of the upper. If the leaf be unfolded, it will be found to contain a very active, wriggling, greenish larva, a little less than an inch long, which is apt to spring out of the fold and fall, or hang by a thread. The leaf itself will be found to be attached to the folded part by means of numerous little cords of silk. If the larva is full grown, the interior of the leaf will be thoroughly skeletonized, and soiled with accumulated excrements. The fold almost invariably brings the upper sides of the leaf together, the larva feeding, therefore, on what would be the upper surface of the leaf. The larva transforms to a reddish-brown chrysalis usually within a much smaller fold of the edge of the leaf, but sometimes within the larger larval fold. The moth, which, during midsummer, issues in a few days, expands about an inch and is a shining opalescent black, with wings bordered with white and marked with white spots, as in the illustration (fig. 102), a slight variation in maculation being noted between the males and females. The moth is seldom seen, but if the vines be shaken it may be frightened up and observed in quick flight seeking other concealment. There are two, or, in the South, three, broods each summer, the last brood hibernating in the leaves very much as does the grape-berry moth, the pupal cases of which are very similar to those of the leaf-folder. It occurs from New England southward to Florida, and westward at least to the Rocky Mountains, and probably is distributed throughout the vine districts of the United States. It affects all kinds of grapes, showing, perhaps, a little preference for the thick-leafed over the thin-leafed varieties.

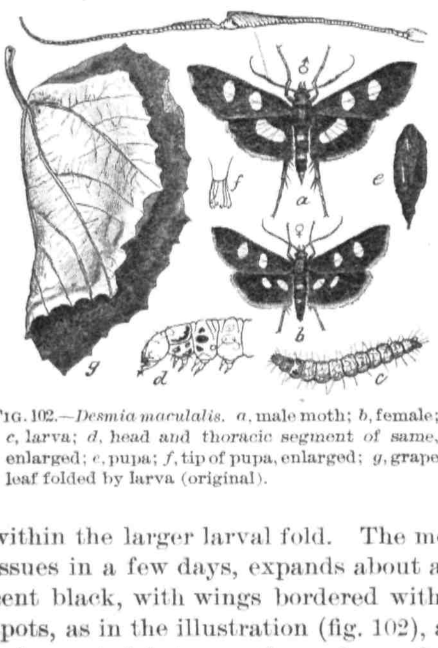

FIG. 102.—*Desmia maculalis*. *a*, male moth; *b*, female; *c*, larva; *d*, head and thoracic segment of same, enlarged; *e*, pupa; *f*, tip of pupa, enlarged; *g*, grape leaf folded by larva (original).

Remedies.—The appearance of a leaf folded by a larva of this insect renders its detection easy, and if the vines are gone over and the larvæ crushed in the folded leaves early in the season when they are few in number, allowing none to escape, later damage may be almost entirely prevented. If the vines are sprayed with arsenicals for other leaf-eating insects, the treatment will destroy all larvæ folding leaves soon thereafter, but not those already present. The ease with which

FIG. 103.—*Philampelus achemon.* *a*, moth; *b*, egg; *c*, young larva; *d*, mature larva; *e*, pupa; *f*, parasitized larva—all natural size (original).

this insect may be destroyed by hand makes it hardly advisable to spray for it alone, and after the grapes have become well formed later in the summer it is no longer safe to spray with arsenicals. Aside from hand picking at this time there is nothing to be done except to adopt measures which will afford protection the following year. These consist in the collection and burning of all fallen foliage as promptly as possible in autumn to destroy the hibernating larvæ and chrysalides.

HAWK MOTHS AND CUTWORMS.

The larvæ of upward of 50 moths feed on the foliage of the grape. Many of these are rare, yet many others are occasionally destructive. Aside from the leaf-folder already discussed, perhaps the leaf-feeding caterpillars oftenest the cause of important damage are the large green or brownish, usually horned, sphingid larvæ and certain cutworms.

Hawk moths.—The larvæ of some ten species of hawk moths or sphingids occur on the grape, and nearly all are widely distributed. The one most frequently met with is the Achemon sphinx (*Philampelus achemon* Drury) herewith figured (fig. 103) to illustrate the characteristics of the group. The sphinx larvæ strip a branch at a time completely, and are, therefore, easily noted. They are not often very abundant and the injury is not usually great, except in the case of young vines, which may be entirely stripped and killed by a single larva. Hand picking is ordinarily the simplest and most satisfactory remedy.

Cutworms.—The climbing cutworms have at times proved very destructive to the buds and foliage of vines, and in northern New York, and particularly in the raisin district of Fresno County, Cal., as much damage has been done by them as by any other insect enemy.

Of the several species which in different localities have been troublesome, the worst record may be assigned to the dark-sided cutworm (*Agrotis messoria* Harr.) and the variegated cutworm (*A. saucia* Hbn.), both occurring throughout the United States, and the ones chiefly concerned in the region noted in California. Cutworms remain concealed in the ground during the day and climb up and strip the vines at night. They may be easily destroyed by the use of a poisoned bait of bran, arsenic (or paris green), and water, preferably sweetened with a little sugar. It should be distributed about the base of each vine in the form of a mash, a handful or so in a place.

THE GRAPE LEAF-HOPPER.

(*Typhlocyba vitifex* Fitch.)

From midsummer to autumn, in increasing amount, the leaves of grapes are affected by a little jumping insect commonly known as the thrips, or leaf-hopper, which works in enormous numbers on the underside of leaves, causing them to appear blotched and scorched or covered with little yellowish or brownish patches, and eventually dry up, curl, and fall. This insect occurs with great regularity wherever the vine is cultivated, and yet so gradually is the damage done that, notwithstanding the great annual loss that must result to grape growers from this insect, no particular effort is ordinarily made to remedy the evil.

The depredator is a very minute insect, not exceeding one-eighth of an inch in length, and has a peculiar habit of running sidewise when

disturbed, like a crab, and dodging from one side of the leaf to the other. It jumps vigorously, like a flea, but also takes flight, rising in swarms when the vines are shaken. If examined without being too much disturbed, they will be noticed thickly clustered over the under-surface of the leaves, busily engaged in sucking the juices of the plant.

Under a lens they will be found to vary considerably in color, and, in fact, they are supposed to represent a large number of distinct species, all closely allied, however, and possessing identical habits. The prevailing color is light yellowish green, with the back and wings variously ornamented with red, yellow, and brown. In the fall they become much darker, though retaining the wing patterns. In any vineyard usually one-half dozen or more color species will occur together, one or two of which will predominate, while only a few miles distant some other forms will be the common ones. The insect figured

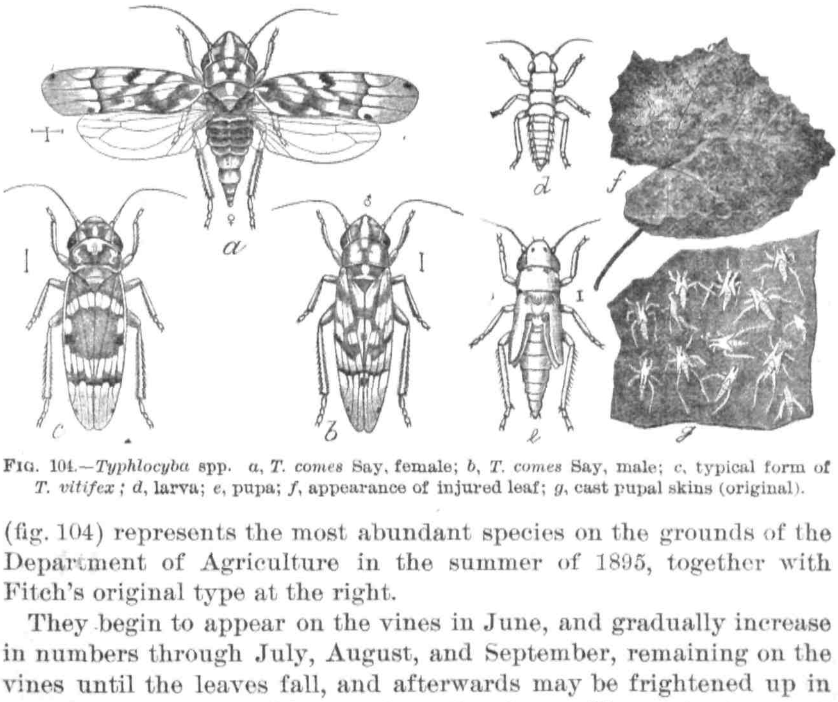

FIG. 104.—*Typhlocyba* spp. *a*, *T. comes* Say, female; *b*, *T. comes* Say, male; *c*, typical form of *T. vitifex*; *d*, larva; *e*, pupa; *f*, appearance of injured leaf; *g*, cast pupal skins (original).

(fig. 104) represents the most abundant species on the grounds of the Department of Agriculture in the summer of 1895, together with Fitch's original type at the right.

They begin to appear on the vines in June, and gradually increase in numbers through July, August, and September, remaining on the vines until the leaves fall, and afterwards may be frightened up in swarms from masses of leaves about the vines. The winter is passed wherever protection may be secured from storms, particularly in masses of accumulated leaves, and especially where these have been blown up against logs or fences. In such situations the writer has observed them by thousands on warm days in early winter. All varieties of grapes are attacked, the thin-leafed sorts most injuriously, but vast injury is done to all, including the wild grapes, and at least one other wild plant—the redbud or *Cercis canadensis*.

Life history.—The eggs are thrust by the female singly into the substance of the leaf on the lower side, either into the midribs and large veins or in the intervening spaces. The young are much like the adults, except that they are smaller and wingless. They cast their skins three times before becoming full grown and acquiring wings, and the white cast skins remain attached to the undersurface of the leaves, frequently upward of 100 clinging to a single leaf. In the middle and southern portions of their range they undoubtedly pass through 4 or 5 broods annually, the life of a single generation probably covering about a month.

Remedies.—The prevention of injury by the leaf-hopper is a very difficult problem. The best chances of relief will come from taking advantage of its hibernating habit and collecting and burning all fallen leaves and any similar material about the vineyards which would furnish it with winter quarters. This will be effective in proportion to the thoroughness with which it is carried out, and the treatment must be extended over a considerable area to give much relief. In this connection it must be remembered that the leaf-hoppers coming from wild grapes or from near-by vineyards are particularly apt to hibernate in woods, returning to the vineyards again the following spring.

Direct measures against this insect consist in spraying with kerosene emulsion or the use of tarred or kerosene shields. The great activity of the insect makes spraying under ordinary circumstances with caustic washes somewhat ineffective, but if the application be made in the early morning or late evening, especially if a cold or moist day be chosen, when the insects are somewhat torpid, considerable benefit will result. The emulsion should be diluted with nine parts water. Applied under the circumstances described, a great many of the leaf-hoppers will be wet with the emulsion or will fly back to the leaves and get it on their bodies before it will have evaporated. The shield method should be used in the warm part of the day, when the insects are most active. A frame with cloth stretched over it and saturated with kerosene or diluted tar may be carried along between the vine rows, the vines being agitated at the same time. The insects will fly up, and all of those striking against the screen will either adhere to the tar or get wet with the kerosene and perish. The shield method, to be effective, must be continued every day or two until relief is gained.

THE GRAPE-BERRY MOTH.

(*Eudemis botrana* Schiff.)

As the grape berries become full grown and begin to ripen, often many of them will be observed to be discolored, and if these be examined a burrow will be found eaten through the pulp from the discolored spot, and within it a whitish larva. These injured berries begin

to appear while the fruit is young and green, and as it ripens they increase in number. Frequently several of these discolored and shriveled berries will be fastened together by silken threads intermixed with the excrement of the larvæ and the sticky grape juice, the larva having passed from one to another. The appearance is not unlike that produced by black rot, and is often confused with the latter. As the larva becomes mature it changes to an olive-green or dark-brown color, and not only excavates the pulp, but burrows into the seeds of the grape. It is very active and is apt to wriggle out of the grape and escape. When full grown, the larva attains a length of about one-third of an inch, and, abandoning the grape, cuts out of a grape leaf a little flap, which it folds over and fastens with silk, forming a little oblong case, in which it changes to a chrysalis. The little slate-colored moth with reddish-brown markings on the forewings appears in ten or twelve days, drawing its chrysalis partly

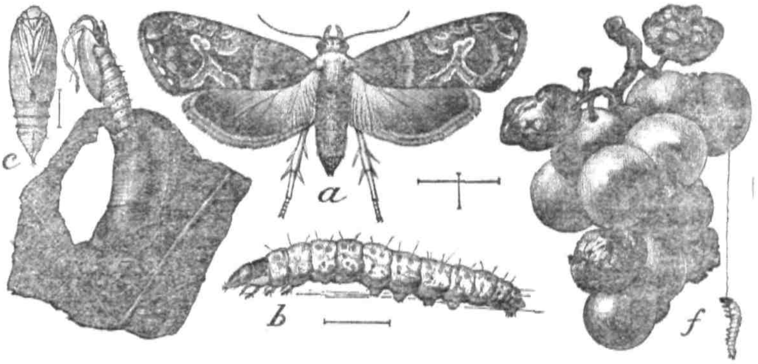

FIG. 105.—*Eudemis botrana.* *a*, moth; *b*, larva; *c*, pupa; *d*, folded leaf with pupa shell projecting from case cut from the leaf; *f*, grapes, showing injury and suspended larva, natural size—all except *f* much enlarged (original).

after it and depositing eggs for an additional brood of larvæ. The last brood of larvæ remains in the leaf cases through the winter. The moths coming from these hibernating chrysalides appear in early spring, and the first brood of larvæ lives on the leaves, tendrils, and blossoms, there being, of course, no grapes for them to infest.

This insect was imported many years ago into this country from southern Europe, where, in Austria and Italy particularly, it is very injurious and has two or three near allies which affect grape leaves and fruit in the same way, but which, fortunately, have not, as yet, been imported into this country, or if so, have not become numerous enough to be recognized. Our grape berry moth is widely distributed, occurring probably wherever the grape is grown to any extent, from Canada to Florida and westward to California. It attacks all varieties, but is especially destructive to grapes with tender skins and such as grow in compact bunches. The records of the Department

show also that this insect is a rather general feeder, and it has been bred from seed bunches of sumac and the leaves of tulip and magnolia. It sometimes enters the leaf galls of the phylloxera and eats not only the interior of the galls, but, as observed by Mr. Pergande, the young and mother louse also. It has proved particularly destructive at times in Ohio, Missouri, and Pennsylvania, and in many cases from 50 to 75 per cent of the crop has been ruined by it. It is probably three-brooded, except in its more northern range, the first brood developing on the leaves in May and June, the second brood on green grapes in July, and the third brood on ripening grapes in August and September. The early brood of this insect is so scanty that it is rarely noticed, and hence protective steps are seldom taken. Later in the season it multiplies with great rapidity, and particularly does it become numerous and destructive if grape gathering be deferred until a late period.

Remedies.—The use of poisons is not practicable except against the first brood, which develops on the green parts of the vine, and here the result is doubtful, because it is more than likely to breed on a great variety of foliage, and spraying would not afford much protection. Bagging the grapes as soon as the fruit sets will undoubtedly protect them from this insect, and at the same time from black rot. Of greater practical value, especially in larger vineyards, is the prompt collection and burning of all fallen leaves in autumn, thus destroying the hibernating larvæ and pupæ, and also the collection and destruction of diseased fruit wherever feasible. Early gathering and shipping or disposal of fruit otherwise is a particularly valuable step, as it insures the removal of the larvæ in the grapes from the vineyard if not their destruction in wine making. All fallen fruit should also be gathered and destroyed.

FOUR COMMON BIRDS OF THE FARM AND GARDEN.

By Sylvester D. Judd,
Assistant Ornithologist, U. S. Department of Agriculture.

The present paper treats of the food habits of the catbird, mocking bird, brown thrasher, and house wren—birds so closely related that ornithologists place them in the same family. A study of the food of these four birds shows that the percentage of animal matter, consisting mainly of insects with a small proportion of spiders and thousand-legs, is greatest in the wren and least in the catbird; the vegetable matter, chiefly fruits, stands, of course, in the reverse ratio. Consequently, of the four birds, the wren is the most beneficial, the whole of its food being insects and their allies; the catbird the least beneficial, because it takes more cultivated fruits than the others. The catbird and thrasher subsist largely on a vegetable diet, consisting mainly of fruits, though the thrasher, especially in spring, before berries and other small fruits ripen, has a decided taste for grain and acorns. For their supply of fruit both birds depend more on nature than on man. Thus the catbird takes twice as much wild fruit as cultivated; the thrasher three times as much. These different proportions of wild to cultivated fruit are probably not due so much to peculiarity of appetite as to dissimilarity in habits.

Insects form the bulk of the animal food of the catbird, mocking bird, brown thrasher, and house wren. Notwithstanding the individual preferences of these birds, they all eat beetles, grasshoppers, ants, spiders, thousand-legs, caterpillars, and, to a less extent, bugs, wasps, and flies. Of all the beetles, ground beetles are the most easily obtained, and consequently are picked up by birds in large quantities. The particular ground beetles eaten by the birds under consideration are only to a slight degree carnivorous; consequently the bird that eats them is not doing the harm that would have been done had beetles of more carnivorous habits been destroyed. Next in importance are the members of a family of beetles known as scarabæids. Those eaten by the wren are the useful little scavenger beetles, while those eaten by the catbird and thrasher are May beetles and their relatives, all of which are injurious to agriculture. Another group of insects largely eaten comprises snout beetles or weevils, of which the plum curculio is a familiar example. These pests, on account of their small size and habit of developing inside the fruit, are very difficult to cope with, because any means of reducing their

numbers is liable to damage the fruit upon which they are feeding. Beetles of other families, such as leaf-eating beetles, click beetles, darkling beetles, longicorn beetles, blister beetles, and beetles of the firefly family, are occasionally eaten. The number destroyed belonging to any one of these families is insignificant, though the total taken from all is considerable.

True bugs, which are bad-smelling insects with sucking mouth parts, are eaten in small quantities by many birds. The bugs eaten by the wren are stink bugs, which feed on plants, and are therefore injurious. On the other hand, many of the large bugs eaten by the thrasher and catbird have predaceous habits, and consequently are beneficial. More caterpillars, harvest spiders, and true spiders are destroyed by the wren than by any of the other three birds. All caterpillars are harmful. Harvest spiders, which prey on plant lice, are useful. True spiders, although carnivorous, may be considered as indifferent, because they destroy useful as well as noxious insects. The same may be said of the small centipedes, which are eaten by the catbird and thrasher. It is quite otherwise with thousand-legs, for they subsist on vegetable matter, and have consequently been regarded as detrimental. They were frequently found in the stomachs of catbirds and thrashers.

The knowledge obtained from the study of the food of the mockingbird is very incomplete. The few stomachs available for examination showed that this bird is fond of grasshoppers; unfortunately, it also likes grapes and figs. The wren is exclusively insectivorous, and therefore highly beneficial to agriculture. The catbird and thrasher do much less good than the wren, because they live on a mixed diet of animal and vegetable food. The good they do depends in the main on the quantity of insects eaten. The proportion of animal matter in the thrasher's food for the entire season is 63 per cent, against 44 per cent in that of the catbird. The thrasher destroys twice as many caterpillars, beetles, and grasshoppers as the catbird, and hence is the more beneficial.

CATBIRD.

The catbird (fig. 106) breeds over a large part of North America, from British Columbia to the Atlantic Seaboard, and from the Southern States northward to the British Provinces. It is most abundant in the Upper Austral and Transition zones of the eastern United States, and throughout most of its range it rears two broods in a season.

Although often nesting in the lilacs that brush against the house, the catbird is in many instances an unwelcome tenant, and is often persecuted without mercy. The cause of this prejudice arises from the bird's fruit-stealing proclivity, and perhaps also from its rasping feline note. Nevertheless stomach examinations show that more than

half of the fruit eaten is wild, and that one-third of the catbird's food consists of insects, many of which cause annually heavy losses to our country. By killing the birds their services as insect destroyers would be lost, so the problem is to keep both the birds and the fruit. Experiments conducted by this division show that catbirds prefer mulberries to strawberries and cherries, hence it may be inferred that these two latter crops may be protected by planting the prolific Russian mulberry, which, if planted in hen yards or pig runs, will afford excellent food for the hens and pigs, besides attracting the birds away from more valuable fruit. Wild cherry, buckthorn, dogwood, wild grape, and elder should be encouraged by the farmer who wishes to escape the depredations of birds and still receive their benefits. It has been shown by Mr. Forbush that by protecting and encouraging native birds in an orchard where heretofore caterpillars had stripped the trees a good crop of apples might be raised.

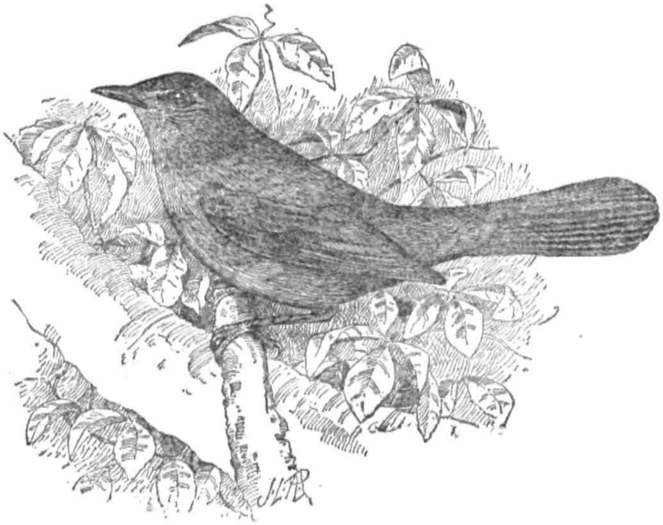

FIG. 106.—Catbird (*Galeoscoptes carolinensis*).

Field reports received from voluntary observers show that catbirds pillage fruit crops in the central part of the United States, where wild fruits are scarce, much more than along the seaboard, where wild fruits grow in profusion. This accounts for such discrepancies as the following. Mr. R. P. Wilson, of Falls City, Nebr., says the catbird is a pest, because of its injury to raspberries, grapes, and apples, while Prof. F. E. L. Beal, of Lunenburg, Mass., says:

On my farm in Massachusetts I have raised strawberries, blackberries, and raspberries by the acre, with grapes, pears, and apples in abundance, and although the farm was nearly surrounded by woods and was adjacent to a swamp where catbirds and thrashers abounded, I never knew one of them to touch a single fruit, though perhaps they have taken a few. I thought no more of accusing the catbirds or robins of fruit stealing than I would the swallows in the barn.

In May, when the catbird arrives from the South, one-third of its food is gleaned from the previous summer's sumac, smilax, and other fruits that have been hanging all winter; but the greater part is derived from the animal kingdom, and consists of ants (15 per cent), thousand-legs (10 per cent), beetles belonging to or having the same habits as the May beetle family, predaceous ground beetles, and caterpillars (each 8 per cent).

For the month of June as a whole, the May ratio of vegetable to animal matter is sustained, but during the latter part of June the proportion of vegetable food increases. As soon as the mulberries, raspberries, cherries, and strawberries ripen, the birds forsake the unsavory winter-cured berries. Early in the season the catbirds eat few grasshoppers and crickets, but during the second and third weeks in June they take so many as to cause a shrinkage in the other animal food. At the time when the birds eat most grasshoppers and crickets, 10 per cent of their food consists of these insects. Prof. S. Aughey examined five catbirds killed in June, and found that the stomach of each contained about 30 grasshoppers. During the last week of June the proportion dwindles, and throughout the remainder of the season it is insignificant. The number of May beetles eaten increases from the 1st of June until about the 20th, after which very few are taken.

As July progresses, the vegetable constituent outstrips the animal by 4 to 1, and maintains this supremacy throughout August and September. During the first twenty days of July the catbird takes the maximum amount of cultivated fruit. Raspberries and blackberries are the favorites, forming the most important element until the middle of August, when they give way somewhat to the black wild cherry, dogwood, and elder berry. Of the animal constituents, the ground beetles and caterpillars fall from their maximum of 6 per cent in June to 3 per cent in July, and then to 1 per cent in August, but rise again in September.

During cold weather, when there is a scarcity of food, birds under stress of hunger eat what would in the time of plenty be disdained. In September the crop of wild fruits is apparently sufficient for ten times the number of birds and mammals inhabiting a particular area, but by the middle of October most of the wild berries have been picked. Although catbirds prefer to make a meal of insects and fruits, in their winter homes they often have to be contented with frozen berries. During the winter months it is probable that the catbird, impelled by hunger, searches out many hibernating insects that under the warming rays of next spring's sun would awaken to lay hundreds of eggs, which would soon hatch into voracious larvæ capable of consuming each day more than their own weight of garden plants.

The testimony of 213 stomachs from points as far west as Kansas,

as far south as Florida, and as far north as Massachusetts, collected from April to December, inclusive, shows that beetles and ants form the most important parts of the animal food of the catbird, though smooth caterpillars play no insignificant part. Crickets and grass-hoppers are relished, and come next in importance. The less important though constant parts of the fare are thousand-legs, centipedes, spiders, and bugs.

Blackberries and raspberries, with wild cherries, mulberries, elder berries, and buckthorn, form the bulk of the vegetable diet, which constitutes more than half of the catbird's food.

The flesh of a berry or fruit has a definite function, which is as important and necessary to the life of the plant as are its roots, for it is by means of the edible qualities of the pulp that the seeds of many plants are scattered. The most active agents in this process of dissemination are birds, which greedily swallow the attractive fruits, the pulp of which is digested, while the seed or stone passes through the intestine and sprouts where it is dropped. In spring and autumn the catbirds plant dogwood, sour gum, smilax, black alder, sumac, and, unfortunately, some poison ivy and poison sumac. It is surprising that birds can eat the fruit of plants which are so poisonous to the human system, and that they relish such highly flavored fruits as spice berries, or the berry of the black alder, which is bitter as quinine.

To what extent cultivated fruit is damaged must be ascertained by observing the birds, because where the bulk of one cherry has been eaten a score may have been pecked, and because the injury of a single grape in a bunch detracts from the value of the whole bunch. Of the stomachs examined, 13 out of the 213 contained strawberry seeds; one bird, shot in a cherry tree, had eaten strawberries, but no cherries; another, from a strawberry patch, contained, besides strawberries, several currants; and 20 of the 213 catbirds had eaten cherries.

Unfortunately, the stomachs available for examination were not accompanied by data as to what fruits the birds had the opportunity of eating, or what plentiful injurious insects had been passed by with indifference. To obtain such data, Prof. F. E. L. Beal and the writer visited, on July 30, 1895, one of the many ravines that intersect one of the bluffs overlooking the Potomac. Here we took note of the insects and berries that were accessible to the birds, in order to learn their preferences when the time came to examine the stomachs.

The particular ravine chosen was about 80 yards wide by twice as long, and extended back at right angles to the river, until it rose to the level of the bluff. On the slanting sides of this depression a belt of catbriers afforded excellent cover for catbirds. Just above the catbriers was a belt of locust trees. The part of the ravine next the

river was swampy, and supported a forest of willows, while the upper part was drier, and afforded an abundance of ripe elderberries and blackberries, upon which catbirds were seen feeding. The birds seemed to devote most of their time to berrying. They were also seen far up in the tops of the locusts, which had been browned as by fire by the locust leaf-miners (larvæ of *Odontota dorsalis*), the beetles of which were swarming in myriads over the leaves. Several male catbirds sang sweetly in the sassafras trees which were sparingly intermixed with the locusts, while others were seen hopping on the ground, where they had a chance to pick up grasshoppers, millers, or ants.

Thirteen of the 15 catbirds seen were shot, and their whole digestive tracts examined; 9 contained the destructive orange and black locust beetle, 18 of which were taken from one bird. This is surprising, because beetles of this family (*Chrysomelidæ*) secrete a substance which is supposed to be distasteful to birds. Every one of the catbirds had eaten elderberries, and all but two blackberries.

The countless numbers of leaf-mining beetles on the trees where the catbirds were feeding, and the consequent ease of obtaining them, are the only tangible facts to account for the rejection of such favorite food as ants and grasshoppers. Not one of the thousands of smooth caterpillars that were stripping the bushes under the willows was to be found in the catbirds, thus showing that these birds prefer beetles to caterpillars.

It is important to know whether a bird prefers wild fruits or cultivated, noxious insects or beneficial. In order to ascertain these preferences a series of experiments was made by the writer. Four catbirds which had been recently trapped were confined in a large cage and yielded many interesting results, a few of which will be cited here. It was demonstrated that smooth caterpillars are preferred to hairy ones, and that butterflies are not relished, though a mourning-cloak butterfly and a hawk moth were eaten after having been chased and battered about the cage for some time. After several unsuccessful attempts one catbird was induced to eat a honeybee. Beetles of the firefly family were eaten under stress of hunger. Small slugs (*Gastropods*), though eaten by one bird, seemed to be regarded as unsavory. Weevils and bad-smelling bugs were eaten with relish, as were also sow bugs. Plant lice were refused, though the ants which tended them were greedily devoured. Maggots were eaten, and a hideous black spider was torn to pieces by all four catbirds, and then eaten with relish. The conclusion suggested by this last experiment was borne out by stomach examination, which showed that 7 per cent of the birds had eaten spiders. About the same number had selected thousand-legs, which subsist on plants and often attack garden vegetables. Owing to their habits of living under stones and other objects on the ground they are not so often picked up as one would expect

from seeing how they were relished by caged catbirds, as were also small harmless centipedes, which have similar haunts but carnivorous habits. These little centipedes were found in several stomachs, as were also small snails which were eaten by the captive birds. Earthworms are not eaten by birds, the robin included, to nearly such an extent as is commonly supposed. Only one out of the 213 catbirds contained an earthworm. More than half of the stomachs examined contained ants, conspicuous among which were two black species, one of which was half an inch long. Ants often make nuisances of themselves by entering houses and getting into the sweets. Many ants tend plant lice, which they pasture and milk at the expense of the farmer. One little brown ant, which raises plant lice among the cherry leaves, was found in many stomachs.

The economic status of the catbird may be summed up as follows: The food consists of 3 per cent of carnivorous wasps and wild bees that carry pollen from flower to flower, but this is counterbalanced by the destruction of weevils, thousand-legs, and plant-feeding bugs. Catbirds have a partiality for the easily obtainable predaceous ground beetles, which are supposed to be beneficial to the farmer, but the loss of these insects is made up for by the destruction of beetles related to the May beetle. The catbird subsists largely on fruit, of which one-third is taken from cultivated crops. It eats caterpillars, grasshoppers, and crickets, with a small percentage of leaf-eating and click beetles. The volume of these insects destroyed is equal to only one-half of that of the cultivated fruit eaten.

BROWN THRASHER.

The brown thrasher (fig. 107) breeds from Dakota to New England, and thence south to Florida. It is most common in the Carolinian zone, where it rears two broods a season. Besides having a more limited range than the catbird, the thrasher is not so abundant, and is less confiding in man, never pouring forth its rich and varied medley from the lilacs under the window, but preferring to serenade from the swaying top of a small tree at the foot of the garden, where a thicket is convenient in case of intrusion. The feet of this shy bird are large and well adapted to a life of scratching for a living among thickets. It prefers to build its nest of coarse rootlets, in old brush piles, but when these can not be found it nests among brambles. The haunts of the thrasher, unlike those of the catbird, may be remote from water courses, though often both birds may be heard singing in the same brier patch.

Reports from field observers state that the thrasher commits depredations on fruit crops, but to a much less extent than the catbird or robin. These reports speak of attacks on black and red raspberries, cherries, strawberries, grapes, plums, peaches, pears, and apples. The fruit grower who sees the birds flocking into his cherry tree not only

neglects to observe the birds sandwiching in with the luscious fruit dainty morsels of insects, but also overlooks the fact that when the cherry season is over they raise havoc among his worst enemies.

Field work, which requires the unprejudiced efforts of a botanist and entomologist, conducted under the most favorable conditions, must be regarded not as a final solution of the problem, but only as an incomplete contribution to our knowledge. In determining the diet of a bird, the examination of the contents of the stomach is, as Professor Beal aptly says, "the court of final appeal." The execution of this method is not only laborious, but difficult, because birds' stomachs may contain anything from a minute fungus cup up to a rabbit. Surpassing the difficulty of investigation, owing to the diversity of bird food, is the difficulty of identifying fruits by little pieces of skin, which

FIG. 107.—Brown thrasher (*Harporhynchus rufus*).

must be subjected to most critical microscopic examination. The proportions of the different elements of the food of the brown thrasher, as determined by an examination of 121 stomachs collected from Maine to Florida and as far west as Kansas, is as follows: Animal matter, 63 per cent; vegetable, 35; mineral, 2.

Beetles form one-half of the animal food, Orthoptera (grasshoppers and crickets) one-fifth, caterpillars somewhat less than one-fifth, bugs, spiders, and thousand-legs about one-tenth. The percentage of food taken from cultivated crops by the thrasher amounts to only 11; of this, 8 per cent is fruit and the rest grain. The farmer is more than compensated for this loss by the destruction of an equal bulk of May beetles, which, if allowed to live, would have done much more harm than the thrashers, and left a multitudinous progeny for next year. The thrasher eats 8 per cent of ground beetles, supposed to be beneficial to the interests of the husbandman. To offset this he destroys

an equal volume of caterpillars, to say nothing of grasshoppers, crickets, weevils, click and leaf beetles. The economic relation of the brown thrasher to agriculture may be summed up as follows: Two-thirds of the bird's food is animal; the vegetable food is mostly fruit, but the quantity taken from cultivated crops is offset by three times that volume of insect pests. In destroying insects, the thrasher is helping to keep in check organisms the undue increase of which disturbs the balance of nature and threatens our welfare. A good example of the result of such irregular increase is to be had in the fluctuations of the Rocky Mountain locust.

The diet of a bird changes with the food supply. Thus when the thrasher returns in April from its sojourn in the Southern States, it takes three times as much animal food as vegetable. Later in the season, but before much fruit is ripe, insects become more abundant. Consequently during May the animal food attains its maximum, outstripping the vegetable by 7 to 1. When the fruits ripen in abundance, however, the proportion of animal food decreases until in September it stands in the inverse ratio of 1 to 2.

Although the thrasher takes its maximum of 17 per cent of cultivated fruit, mainly red and black raspberries, with a few currants, in July, the horticulturist at this time does not mind the loss, because there is plenty; on the contrary, when cherries and berries first commence to ripen they bring good prices and the loss is keenly felt. During the first half of July, mulberries form an important element of the vegetable food, but soon buckthorn comes in and continues to play an important part in August until the black wild cherry, elder, dogwood, and other fruits become plentiful. Ants attain their maximum during the month of July, and, with equal volumes of May beetles and caterpillars, compose one-fourth of the food for the month. Caterpillars, which reach their maximum in June, are almost forsaken in July for the ripening fruits, thus falling to 4 per cent, a proportion which is maintained throughout September. During August the animal matter continues to fall off; nevertheless a great many bees and wasps are eaten, while more ground beetles are taken at this time than at any other. For the month of September two-thirds of the food of the thrasher is fruit. Of the insects, grasshoppers and crickets have been steadily decreasing since June, and the May beetle has also been decreasing until in September it is no longer found. Bugs which crawl over clusters of fruit, often getting into one's mouth to leave a disgusting taste, rise in September to a maximum of 5 per cent. In October only two stomachs were collected; one was packed with dogwood berries, while the other contained a number of elder berries and the grinder of a grasshopper's jaw. A bird killed on the 22d of November had eaten a grasshopper, several seeds of sumac and poison ivy, and some mast.

It is much regretted that no winter birds were examined. The

thrasher and catbird when they migrate to the South in autumn become very shy, preferring thickets remote from dwellings; and it is probable that in the South these birds not only do no harm, but on the contrary do much good in searching out hibernating insects, which if allowed to live might lay countless eggs, to hatch and threaten next year's crops.

If a series of experiments similar to those carried out with the catbird could have been performed, the economic value of the thrasher would have been determined with greater accuracy, for only by experiment is it possible to ascertain a bird's preferences in the matter of food and the quantity eaten in a given time. Thus, caged catbirds refused bristly caterpillars, were specially fond of ants, and preferred mulberries to cherries. Birds selected for experiment should be adults recently trapped, because those that have been long in confinement usually develop unnatural tastes. A tame thrasher, which was raised from the nest and had been in captivity four years, was equally fond of roast beef and broiled chicken, and ate bread three times a day. Members of the family frequently caught for him flies, grasshoppers, meal worms (beetle larvæ), and millers, which he appreciated to the utmost. In order to prove or disprove the statement that leaf-eating beetles are distasteful to birds, he was offered a spotted squash beetle, which he immediately swallowed. On three occasions potato beetles were put in the cage. These after having been thrashed about on the floor for several minutes were swallowed and then disgorged, but in two instances parts of the beetles were again swallowed. When offered a squash bug, he tore it to pieces and devoured it, but kept shutting and opening his eyes as though disturbed by the nauseating odor. When a ground beetle (*Harpalus caliginosus*) was placed in the cage, he acted in the same way. Two hairy caterpillars were offered him; the first, a fall webworm, was refused; the second, a bristly brown caterpillar, was seized and rubbed on the floor of the cage until devoid of bristles, then swallowed, to be immediately disgorged. Several green caterpillars of the cabbage butterfly were eaten with relish, showing, as with the catbird, that smooth caterpillars were preferred to hairy ones. This thrasher relished blackberries, raspberries, strawberries, grapes, apples, pears, and peaches. In the woods the writer has seen thrashers feasting on the bitter sour gum berries with the flickers and robins; the thrashers were also eating frost grapes and pokeberries. Some pokeberries and sour gum were picked and offered to the caged thrasher; he seized the stem attached to a sour gum berry, swung it around his head, and let it go across the cage like a hammer thrower. After repeating this athletic feat several times, he ate the berries. When fed exclusively on mocking-bird food for seven days, the average quantity consumed in a day weighed, dry, half an ounce.

The brown thrasher in its present numbers is a useful bird, and should be strenuously protected from gunners and nest-plundering

boys. It is to be regretted that a bird of such harmonious coloring, coupled with a sweet, ringing voice, is so shy and distrustful.

MOCKING BIRD.

The mocking bird (fig. 108), famous in both hemispheres, is a Southern bird, breeding from Virginia, southern Illinois, and Kansas southward. It is found also in Arizona, Utah, Nevada, and southern California, and is particularly abundant along the seaboard of the Southern States, where it often raises three broods a year. The mocker is seldom seen remote from plantations, since, like the robin, it loves the habitation of man. It often chooses as a building site an orange tree in the planter's dooryard, where it constructs its inartistic nest of sticks lined with soft materials, in which to lay its clutch of brown-blotched, greenish eggs. During the period of incubation the song of the mocker is at its best, and is heard at night from the male perched

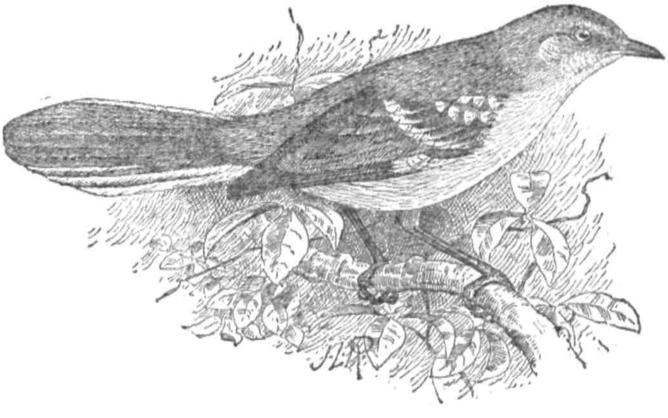

FIG. 108.—Mocking bird (*Mimus polyglottos*).

on the gable. Despite this token of its confidence in man, a planter in Florida killed over a thousand mockers and buried them under his grapevines because they had taken some fruit.

In southern Texas the mocker is so abundant that it is always in sight. Here the bird does some damage to cultivated fruit. Dr. E. P. Stiles, writing from Austin, Tex., states that it damages fruit, chiefly peaches and grapes, and that to prevent its ravages it is a common practice to tie up the vines in mosquito netting. In southern California Mr. F. Stephens reports that mockers eat figs, and from Florida Mr. S. Powers writes, "Mockers eat strawberries to some extent, but it is only when the patch is a small one, or very early in the season, when the berries are few and worth $3 a quart, that anybody feels the loss from them." On the other hand, the mocking bird is known to destroy many insects. Dr. E. P. Stiles states that in Texas it eats

large spiders and grasshoppers, and the late Prof. C. V. Riley, in the Fourth Annual Report of the United States Entomological Commission, enumerated it among the enemies of the destructive cotton worm.

Only 15 stomachs of the mocking bird were examined, and most of these were taken in autumn and winter, the seasons when the greatest proportion of vegetable food is eaten. In these stomachs the quantity of vegetable matter was decidedly in excess of the animal matter. The former consisted for the most part of the skin and pulp of some large fruit, together with seeds or berries of sumac, smilax, black alder, poison ivy, virginia creeper, red cedar, pokeberry, mulberry, and bayberry. The animal food consisted wholly of spiders and insects. Among the latter were ants, caterpillars, beetles, and grasshoppers. While the available data are far too imperfect to form the basis of any generalization with regard to the mocking bird's food, there is nothing in the facts at hand to indicate that it differs materially from that of its relatives, the catbird and thrasher.

HOUSE WREN.

The sprightly little house wren (fig. 109), that carols from the fence post while its mate sits snugly on her clutch of reddish-brown eggs in the box on the veranda, is distributed throughout the United States, except in the mountainous districts. After wintering in the Southern States it returns to the Northern States about the first of May, and, like the bluebird, nests in holes. It is nothing daunted by the size of the cavity, and often takes quarters large enough for an owl. In one instance a pair of wrens chose a watering pot hanging on the back porch. To this they carried twigs until the cavity was filled. Then the nest proper, of soft materials lined with feathers from the barnyard, was placed in the midst of the sticks. Six to eight eggs are laid, and two broods are raised in a season. The parent birds hunt through orchards and along fences, peering into every nook and cranny for insects to feed their clamorous youngsters. When the nestlings are fledged, the parents conduct them with the greatest care about the vicinity of the nest and teach them to catch insects. A whole family may often be seen scurrying about in a brush heap. In case of danger they do not fly, but bury themselves in the bottom of the heap for a few moments, and then poke their heads out like mice.

The house wren is beloved by everyone, and recognized by the husbandman as a destroyer of insect pests. None of the field reports sent to the division contain complaints against the wren, while all speak of it as one of the most useful birds of the farm. In the laboratory these reports have been substantiated; 98 per cent of insects and their allies was found in 52 stomachs collected from Connecticut to Georgia, and as far west as California. The 2 per cent of material as yet unaccounted for consisted of such rubbish as bits of grass or wood and sand, which in all probability was taken accidentally.

Half of the food of the wren consists of grasshoppers and beetles; the other half is made up of approximately equal quantities of caterpillars, bugs, and spiders. Several of the most important families of beetles were represented. Among them the omnipresent little ground beetle formed 6 per cent; weevils, which amounted to 11 per cent of the food in June, ranked next in importance. Wrens eat about half as many little dung beetles as weevils. The former amount to 10 per cent of the food in May, but are not eaten later in the season. Beetles belonging to other families amount to 8 per cent. One bird had eaten a beetle of the firefly family, another a leaf beetle, and three birds had eaten click beetles. Rove beetles were found in two stomachs. One wren had eaten a longicorn beetle.

FIG. 109.—House wren (*Troglodytes aëdon*).

Common grasshoppers, green grasshoppers, and crickets form the most important part of the house wren's food, reaching a maximum of about 60 per cent in August, and practically excluding many heretofore conspicuous elements. The catbird and thrasher stop eating grasshoppers when fruit ripens, but the wren keeps right on with the good work.

The bugs eaten by wrens include many plant-feeding stink-bugs (*Pentatomidæ*), leaf-hoppers, and in one instance plant lice, but this good was more than counterbalanced by the destruction of daddy longlegs, which subsist largely on aphids. The scales of butterflies or moths were found in two stomachs. Flies, though relished by birds,

are too wary to be caught in large numbers. Only five of the wrens examined contained flies. Wasps were detected in three instances.

From the foregoing detailed account of the wren's food, it is obvious that the bird is very beneficial to agriculture. Such insectivorous birds should be encouraged. It is a pity that the quarrelsome English sparrow can not be exterminated, for if in place of every dozen sparrows there was one house wren, our churches and statues would present a more sightly appearance, while in the country the yield of crops would be greatly increased. At Cambridge, Mass., the sparrow has driven the wren away by occupying its nesting places. This is true to a certain degree wherever the two birds have met. To secure the services of the wren, the farmer must put up nesting boxes and declare war against the sparrow.

Table showing number of stomachs examined and percentages of food constituents.

	Catbird.	Brown thrasher.	House wren.
Number of stomachs	213	121	52
Percentages of animal foods:			
Ants	10	5	4
Caterpillars (*Lepidoptera*)	5	8	16
Beetles (*Coleoptera*)	14	28	22
Grasshoppers, etc. (*Orthoptera*)	4	12	25
Bugs (*Hemiptera*)	2	2	12
Spiders and thousand-legs, etc. (*Arachnida* and *Myriapoda*)	4	7	14
Miscellaneous animal food	5	1	5
Total animal	44	63	98
Percentages of vegetable foods:			
Cultivated fruits	18	8	....
Wild fruits	35	24	....
Grain	....	3	....
Miscellaneous vegetable food	2	....	1
Total vegetable	55	35	1

THE MEADOW LARK AND BALTIMORE ORIOLE.

By F. E. L. Beal,
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The oriole family includes the true orioles, the blackbirds, and the meadow larks. The different members of the tribe differ greatly among themselves in form, plumage, and habits. While the true orioles are strictly arboreal, hanging their nests among the most inaccessible twigs of tall trees, the meadow larks are mainly terrestrial, placing their humble domiciles on the ground or even sunken a little below the surface. Between these extremes come the blackbirds, some of which, as the redwing, breed among reeds and in low bushes, while others, as the crow blackbird, nest chiefly in the tops of trees. As might be expected, the feeding habits of these birds differ greatly. The oriole seeks its food almost exclusively in trees, while the meadow lark is a ground feeder. Consequently, the kinds of insects eaten are not the same. The oriole feeds largely on caterpillars and wasps, which live among leaves and flowers; the meadow lark, on the other hand, eats grasshoppers and other ground insects. After a careful consideration of their food, one can hardly fail to be impressed with the fact that both of these birds must be eminently useful to the farmer.

In the case of the meadow lark, insects constitute a large percentage of the food, and even in the winter months, when the ground is covered with snow, they form a very important element. The great bulk of these are grasshoppers, insects whose ravages have been notorious from earliest times and whose devastations in the Mississippi Valley are still fresh in the minds of the farmers of that region. The number eaten is so enormous as to entitle the meadow lark to rank among the most efficient of our native birds as a grasshopper destroyer. Nor are the other components of its insect food less important except in quantity. Some of the most injurious beetles form a considerable percentage of the stomach contents, while the useful species do not appear so often as might be expected from the terrestrial habits of the bird. The other insects eaten—ants, bugs, caterpillars, and beetle larvæ—are almost all destructive, and their consumption by birds is a decided benefit to man.

The oriole, although differing radically from the meadow lark in food and manner of life, is not the less beneficial from an economic point of view. It is a most potent factor in the destruction

of caterpillars, eating so many that if no other insects were taken it would still be classed as a useful bird. It does not, however, restrict its diet to caterpillars, but eats great numbers of injurious beetles, and also many bugs and grasshoppers. In the matter of vegetable food the record is nearly as good, for although corn, peas, and a few fruits are eaten, they appear in such small quantities as to have little economic significance.

FOOD OF THE MEADOW LARK.

The common meadow lark is a familar bird of the open country throughout the United States, although it is less abundant in the desert areas. Alike on the meadows of the East, the prairies of the West, and the savannas of the South, its clear pipe may be heard in the spring, announcing the return of the season of mating and nest building. It chooses for its home meadow lands or other level ground free from trees, and, if possible, near a supply of water, for it delights to drink and bathe in clear running brooks. Its nest, usually over-arched to protect the eggs and the sitting bird from the weather, is built on the ground among last year's herbage, and is often so completely hidden as to defy the efforts of the most skillful searcher. The bird's preference for unmown fields, covered with what farmers call "old fog," has given rise to the name "old-field lark," by which it is known in some places.

While the great bulk of the species migrate from the Northern States, small flocks sometimes remain throughout the winter. South of the latitude of Pennsylvania the birds may be found at all seasons, though in somewhat reduced numbers during the colder months. Early in March they begin to move northward, and soon spread over the whole northern United States and extend into Canada. The southward migration begins in September, and by the end of October all are gone.

The common meadow lark (*Sturnella magna*) inhabits the eastern United States and ranges as far west as the Great Plains. The Western form (*S. neglecta*) is mingled with it in the Mississippi Valley, and thence to the Pacific Coast replaces it completely. The economic aspects of the two birds are practically the same.

As a rule farmers do not look upon the meadow lark (fig. 110) as an injurious bird, though a few complaints against it have been received. It has been accused of pulling sprouting grain and of eating clover seed (presumably newly sown) to an injurious extent. As these are the only charges of any consequence among thousands relating to damage done by other birds, it appears that the food habits of the meadow lark do not materially conflict with the interests of the farmer. This supposition is fully substantiated by the result of examinations of the contents of the bird's stomach, and it is still further shown that, far from being injurious, it is one of the most useful allies to agriculture, standing almost without a peer as a destroyer of noxious insects.

In the laboratory investigation of the food of the meadow lark, 238 stomachs were examined; these were collected in 24 States, the District of Columbia, and Canada, and represent every month in the year. A summary of the stomach contents for the whole year is as follows: Insect food, 71.7 per cent; vegetable food, 26.5; mineral matter, 1.8. Excluding the mineral element, which is not food, the record stands: Animal matter, 73 per cent; vegetable, 27. In other words, nearly three-fourths of the meadow lark's food for the year, including the winter months, consists of insects.

In August and September the meadow lark subsists almost exclusively on insect food, but this is not surprising, as insects are abundant at this season. In March, however, insects are not readily found; yet the meadow lark finds enough to make 73 per cent of its entire food. Similarly in December and January the insect food amounts to 39 and 24 per cent, respectively.

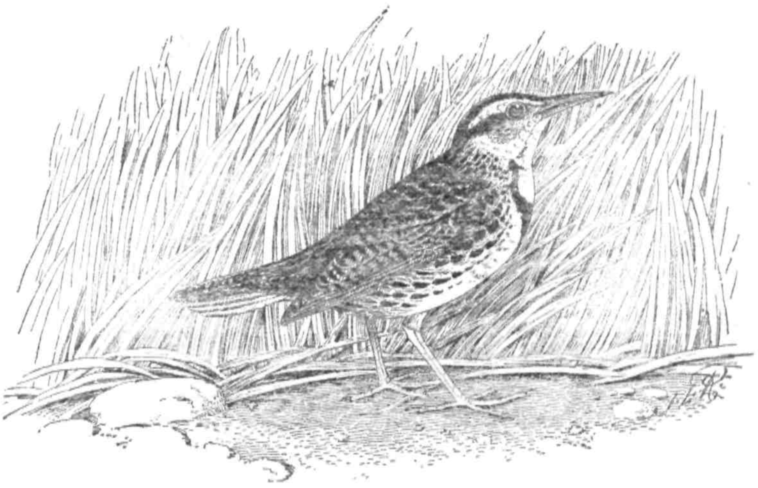

FIG. 110.—Meadow lark (*Sturnella magna*).

As an illustration of the meadow lark's vigilance in searching for insects, an instructive lesson may be drawn from the examination of the stomachs of 6 birds killed in Virginia when the ground was covered with snow. The smallest quantity of insect food in any one of the 6 stomachs was 8 per cent of the contents, the largest quantity 95 per cent, and the average for all 6 more than 47 per cent, or nearly half of the total food. The insects consisted of beetles of several species, bugs (*Hemiptera*), grasshoppers, crickets, a few wasps, caterpillars, spiders, and myriapods. Thus it is evident that insects form an essential element of the bird's diet, and are obtained even under very adverse circumstances.

Of the total insect food of the 238 birds examined, grasshoppers, locusts (green grasshoppers), and crickets constitute by far the most

important element, averaging 29 per cent of all food consumed during the year. Even in January they form more than 1 per cent, and increase rapidly until August, when they reach the surprising amount of 69 per cent. They decrease slowly during the autumn months, but in November still amount to 28 per cent, but naturally fall away quickly in winter. It is extremely doubtful if any other bird will show a better grasshopper record than this. Professor Aughey, in his report on the insects eaten by the birds of Nebraska (First Annual Report U. S. Entomological Commission, 1877, Appendix II, p. 34), credits the meadow lark with destroying large numbers of grasshoppers. It should be borne in mind that the birds which form the subject of this paper were not collected in any region especially infested with grasshoppers, but were gathered from nearly all parts of the United States. Out of the whole number of stomachs (238), 178 contained grasshoppers, one containing as many as 37. Of the 28 birds taken in August, in seven different States, all but one contained them, and one stomach, from New York, was filled with 30 common grasshoppers, 14 green grasshoppers (*Locustidæ*), and 10 crickets. Of 29 stomachs collected in seven States in September, every one contained grasshoppers, and two contained nothing else. Of the 40 stomachs collected in October from ten States, all but two contained grasshoppers and crickets.

Dr. A. K. Fisher has made some interesting calculations upon the amount of hay saved by the destruction of grasshoppers by Swainson's hawk, and it would not seem to be out of place to attempt to reduce to a numerical basis the good done by the meadow lark in the consumption of these insects. Dr. Fisher gives the weight of an average grasshopper as 15.4 grains, and entomologists place the daily food of a grasshopper as equal to the creature's own weight, an estimate probably much within the limit of truth. Remains of as many as 54 grasshoppers have been found in a single meadow lark's stomach, but this is much above the number usually eaten at one time. Such food, however, is digested rapidly and it is safe to assume that at least 50 grasshoppers are eaten each day. If the number of birds breeding in 1 square mile of meadow land is estimated at 5 pairs, and the number of young that reach maturity at only 2 for each pair, or 10 in all, there will be 20 birds on a square mile during the grasshopper season. On this basis, the birds would destroy 30,000 grasshoppers in one month. Assuming that each grasshopper, if let alone, would have lived thirty days, the thousand grasshoppers eaten by the larks each day represent a saving of 2.2 pounds of forage, or 66 pounds in all for the month. If the value of this forage is estimated at $10 per ton (which is below the average price of hay in the Eastern markets), the value of the crop saved by meadow larks on a township of 36 square miles each month during the grasshopper season would be about $24.

Beetles of many species stand next to crickets and grasshoppers in

importance, and constitute nearly 18 per cent of the annual food, but as these insects vary much in their economic relations it will be best to consider the different families separately. Among the most important are the May beetles (*Scarabæidæ*), a family which contains some of our most injurious insects as well as many harmless species. But as the great majority of the members live upon vegetable food, and may at any time turn their attention to useful plants, the whole family may be classed as potentially harmful, consequently the birds do no harm by eating them. The average consumption of May beetles amounts to about 4 per cent of the entire food of the year. The greatest numbers are eaten in May, when they form over 21 per cent of the food. Most of these are dung beetles, but some remains of the well-known Lachnosterna are found. The snout beetles, or weevils (*Rhyncophora*), form a small but very constant element, averaging about 3 per cent for the year. June shows the greatest consumption, with over 7 per cent, and, singularly enough, January stands next, with almost 5 per cent. The principal families represented are the curculios (*Curculionidæ*) and the scarred snout beetles (*Otiorhynchidæ*), both of which include some of the most harmful insects known, and no useful ones. The plum curculio (*Conotrachelus nenuphar*) is a well-known example.

Other beetles, belonging to about a dozen families, collectively form about 3 per cent of the whole food. Of these the most interesting are the leaf beetles (*Chrysomelidæ*), which are supposed to be disagreeable to birds, but whose remains were found in 19 of the 238 stomachs examined. The Colorado potato beetle is a member of this family, and while none were actually found, it seems highly probable that meadow larks might eat them if they fell in their way.

One of the important questions in regard to the diet of insectivorous birds is the extent to which they eat predaceous beetles (*Carabidæ*), for many of these beetles are beneficial. From its ground-feeding habits the meadow lark might be expected to subsist largely upon carabids, as they also live mainly upon the ground and are very abundant. The examination shows that these insects constitute something more than 7 per cent of the food during the year, but are very curiously distributed, attaining maxima of 20, 16, and 17 per cent, respectively, in March, July, and November, while the minimum records (less than 1, 2, and 4 per cent) fall in January, May, and September. This is certainly a very moderate showing when it is considered that the meadow lark feeds almost exclusively on the ground where these beetles are so abundant, and it seems to indicate that instead of seeking them the bird simply eats such as fall in its way in default of better food.

Bugs (*Hemiptera*) are pretty regularly eaten throughout the year, averaging 4 per cent of all the food. The greater number belong to the family of stink bugs (*Pentatomidæ*), some of which are familiar

to all who have eaten raspberries from the vines. Those who have by accident tasted the bugs will never forget the flavor and will wonder that any bird habitually eats such highly seasoned food. Most of these bugs are eaten in March, when they constitute 14 per cent of the food of the month. While some of them are harmful as well as disgusting, others do much good by devouring other insects, so that the destruction of the various members of this family is not an unmixed benefit. It is important to note that one stomach contained three specimens of the notorious chinch bug, an insect whose ravages in our wheat and corn fields have cost the country millions of dollars.

Caterpillars, or the larvæ of butterflies and moths, form a very considerable part of the food of the meadow lark, but the adults are rarely eaten, only three small moths having been found in the 238 stomachs. Caterpillars were present in every month except February, and even the stomachs taken in December contained 4 per cent of this food, while the average for the year is nearly 8 per cent. From the terrestrial habits of the meadow lark, it is evident that the caterpillars eaten must be species that live on or near the ground and feed on grass or other low plants. To this category belong the various species of cutworms. A number of these were identified in the stomachs, and no doubt many more were eaten, but they are so fragile and so soon reduced to fragments by the stomach's action that specific identification is always difficult and often impossible.

The larvæ or young of beetles were found in every month except February, and formed more than 3 per cent of the food of the year. They increased to 11 per cent in May, and were sufficiently numerous to be important throughout the season except in August, September, and October, when they amounted to less than 1 per cent.

Ants form a fairly constant element of the meadow lark's diet, averaging a little less than 3 per cent for the year. None were found in January, but in April they formed 4 per cent of the food. They decreased during the succeeding months, but increased suddenly to over 16 per cent in September, after which they again fell to an insignificant figure. Other Hymenoptera (wasps, etc.) average about 1½ per cent for the year, and are only important in June and July, when they amount to 6 and 4 per cent, respectively. Spiders and myriapods (thousand-legs) seem to be eaten quite freely, and aggregate nearly 5 per cent of the food. The largest number (8 per cent) are eaten in March and December, but the percentage falls off during the winter and in midsummer. Besides the insects already mentioned, several were found representing other orders. Flies (*Diptera*) were contained in a few stomachs, a dragon fly (*Odonata*) in one, an earwig (*Forficulidæ*) in one, and a common cattle tick (*Ixodes*) in one. Snails, or fragments of their shells, were found in seven stomachs, sow bugs (*Oniscus*) in two, a small crustacean in one,

and the bones of small frogs or toads (*Batrachians*) in three. These last were from stomachs taken in Florida, and do not appear to be a favorite food.

From the foregoing, it is evident that the meadow lark is preeminently an insect eater; still it has recourse when necessary to vegetable food.

As before stated, the total vegetable food for the year amounts to 27 per cent. Of this, grain (corn, wheat, and oats) aggregates 14.4 per cent, or a trifle more than half. The percentages of the different kinds of grain are: Corn, 11.1; wheat, 1.8; oats, 1.4. The largest quantity of grain was eaten in January, when the stomachs contained 53 per cent of corn, 11 per cent of wheat, and 9 per cent of oats. During the summer months the grain disappears, to appear again as the supply of insects fails. Sprouting grain was not found in any stomach. In April the total amount of grain was a little less than 15 per cent, and this may have been taken from newly sown fields. In May no wheat or oats were found, and only 1.9 per cent of corn.

Seeds of plants classed as weeds were found in every month except May, and it is probable that a greater number of stomachs in that month would have shown at least a few. Excepting the single stomach taken in February, which contained 75 per cent of barn-grass seed (*Chamœraphis*,) weed seeds attain their maximum of over 25 per cent in December. The average for the year is a little more than 11 per cent, or the same as corn. The remaining vegetable food averages less than 1 per cent. Fruit seems to be accidental, each of the varieties named having been found in only one or two stomachs, and in small quantity. The same is true of the articles enumerated in the miscellaneous list. Complaints have been made against the meadow lark on the score of eating newly sown clover seed to an injurious extent; this seed, however, was found in only six stomachs, and each contained but a few seeds.

The testimony of the stomachs does not indicate that grain is preferred to other seeds, and it can not be urged that it is less easily obtained than seeds of weeds, for grain is a prominent crop throughout much of the country inhabited by meadow larks, and on account of its larger kernels is picked up more easily than smaller seeds. The meadow larks might be expected to injure grain when they collect in flocks, as they sometimes do, but at the time of harvesting wheat and oats they are not found in flocks, and the record shows that practically no wheat or oats were found in the stomachs, it being the season when insects were most abundant and formed nearly the whole food. As an illustration, the stomach of a bird killed in a field of shocked oats contained nothing but insects. In September and October, when corn is being harvested, the amount of this grain found in the stomachs was less than 1 per cent. In November, when insects begin to fail, the vegetable food increases, but it is worthy of note that weeds (*Ambrosia*,

Chamæraphis, etc.) are preferred, for in this month grain amounts to only 6 per cent, while weed seeds reach 15 per cent.

In summing up the record of the meadow lark, two points should be especially noted: (1) The bird is most emphatically an insect eater, evidently preferring insects above all other food; and (2) in default of its favorite food it can subsist on a vegetable diet. Prof. S. A. Forbes, in discussing the food of predaceous beetles (Bull. Ill. State Lab. Nat. Hist., Vol. I, No. 3, p. 159), calls attention to the fact that species which are able to vary their diet and subsist upon vegetable food when their ordinary supply of insects fails, are much more valuable than those which are entirely carnivorous. This is exactly the case with the meadow lark. For this reason a relatively short migration enables it to bridge over periods of scarcity of its favorite food.

FOOD OF THE BALTIMORE ORIOLE.

The Baltimore oriole, golden robin, or hang-nest (fig. 111), as it is variously called, is so well and so favorably known throughout the country that it may seem almost unnecessary to show that its food habits are as beneficial as its song and plumage are pleasing. In most places where this bird makes its home, the people, especially the farmer-folk, would no more think of killing it or destroying its nest than would the Hollander shoot the stork that nests on his roof.

The Baltimore oriole (*Icterus galbula*) breeds throughout the eastern United States north of Virginia, and reaches somewhat farther south in the Mississippi Valley. It is abundant in New England, and extends west over the tree-covered parts of the Great Plains, beyond which it is replaced by another species of much the same appearance (*I. bullocki*). In New England the oriole usually comes with the flowering of the apple trees, in the latter half of May; in the West it appears somewhat earlier. As its food consists largely of insects that live in the foliage of trees, its arrival in the North is delayed until these have become plentiful. It begins to move southward early in August, and is rarely seen in September, though one of the specimens examined was taken in Connecticut as late as November 16; but this must be regarded as a belated straggler. The species passes south of the United States, to spend the winter in the warmer countries beyond.

The present preliminary report is based on the examination of the contents of 113 stomachs, collected in 12 States, the District of Columbia, and Canada, and ranging from Massachusetts, on the east, to Kansas and North Dakota, on the west. They were all collected during the months from April to August, inclusive, with the exception of a single specimen taken in November. They are distributed by months as follows: April, 2; May, 45; June, 32; July, 18; August, 15; and November, 1.

The food for the whole season consisted of 83.4 per cent of animal matter and 16.6 per cent of vegetable matter. The mineral matter

found in the stomachs is not really food, and was taken in such small quantities that it may be disregarded. As April is represented by only two stomachs, and November by one, the results for these months can not be considered as final. Excluding November, the largest amount of insect food was eaten in May, when it formed 92 per cent of the food, and the smallest in April and July, when it formed 70 per cent. The single November stomach contained 98 per cent of insects.

The most important item of the insect food is caterpillars, which aggregate more than 34 per cent of the whole. Contrary to what might have been expected, the Connecticut stomach taken in November contained 81 per cent of these insects. This accords with what has been noted by many observers in the field, that the oriole spends a

FIG. 111.—Baltimore oriole (*Icterus galbula*).

great deal of time searching among leaves and branches, where such insects abound. An average of 25 per cent of caterpillars was found in the two stomachs taken in April, and this percentage continued without much variation until July, when it dropped to 12, July being the month when most fruit was eaten. After July the percentage of caterpillars eaten increases rapidly.

Beetles of various families and species rank next to caterpillars in abundance. Those most eaten are the click, or snapping, beetles (*Elateridæ*), insects having very hard shells, which would seem to render them undersirable for food. Although eaten during May, June, and July only, click beetles constitute 9 per cent of the food for these months, or 4.5 per cent for each of the six months under consideration.

These beetles and their larvæ, known as "wireworms," are among the most destructive insects with which the farmer has to contend. Professor Comstock says of the click beetles:

There is hardly a cultivated plant that they do not infest; and working as they do, beneath the surface of the ground, it is extremely difficult to destroy them. Not only do they infest a great variety of plants, but they are very apt to attack them at the most susceptible period of their growth, before they have attained sufficient size and strength to withstand the attack, and often the seed is destroyed before it has germinated. Thus fields of corn or other grain are ruined at the outset.

As there are over 500 species of snapping beetles in North America, it is easy to understand how welcome is any assistance in the struggle against them, and it is gratifying to know that the oriole is especially fond of them.

The May beetles (*Scarabæidæ*) stand next to the click beetles in importance as food of the oriole. They were found in stomachs collected during every month from May to August, but only in May and June was the percentage important, viz, 12 and 7 per cent, respectively. The average for the whole season was 3½ per cent. These insects consisted of the common May beetle (*Lachnosterna*), several species of dung beetles (*Aphodius*), and a number of the leaf-eating beetles (*Dichelonycha*). So far as known dung beetles do no harm, but the other two genera are very injurious. Leaf beetles (*Chrysomelidæ*) are not supposed to be a favorite food of birds, owing to their disagreeable excretion, but they were eaten by the orioles in every month except November. In July they amounted to 8 per cent, in August 5, and averaged nearly 3 per cent of the food for the season. More than half a dozen species belonging to this family were identified in the contents of the stomachs. Among them was the well-known striped squash beetle (*Diabrotica vittata*), which in the larval state bores the roots of squashes or cucumbers, and when adult feeds on their leaves.

Another member of the same family (*Odontota dorsalis*) feeds on the leaves of the locust, and in some places ruins the trees, while another of the same genus (*O. rubra*) feeds on apple trees. Both of these were identified in the stomachs. Snout beetles or weevils (*Rhyncophora*) form a small but fairly constant element of the oriole's diet, amounting to a little more than 2 per cent for the season. In May they formed 5 per cent of the food, and then decreased to less than 2 per cent in July, but in August increased a little. All are noxious insects, and belong for the most part to the families of the curculios and the scarred snout beetles (*Otiorynchidæ*). Members of six other families of beetles were found, but not in sufficient numbers to be of economic importance, although it is interesting to note that one of the blister beetles was among the number. As most of these beetles contain a secretion that produces blisters, it would seem to us that they must be rather disagreeable as an article of food.

The predaceous beetles (*Carabidæ*) constitute an element of great interest in the food of any bird, since the number eaten is commonly taken as a criterion of the comparative usefulness of the bird. As these beetles themselves live for the most part on other insects, it is evidently desirable that they should be allowed to pursue this good work as long as possible. That they are not molested by orioles is proved by the fact that in the stomachs examined predaceous beetles averaged only one-half of 1 per cent for the season, and the greatest number taken in any month amounted to little more than 1 per cent.

Wasps (*Hymenoptera*) constitute an important element of the food in every month, varying from 20 per cent in April to about 8 per cent in July, and averaging nearly 11 per cent for the season. As these insects spend a large part of their time buzzing about flowers and leaves, it seems only natural that they should be eaten by the oriole. Ants, which also belong to the *Hymenoptera*, are eaten to some extent through the spring and summer, but are only important in April and May, when they form about 10 per cent of the food. They belong for the most part to the large black species of *Camponotus*, which live on trees and nurse plant lice.

Bugs (*Hemiptera*) of various species are favorites with the orioles, as they are with many other birds, and form about 6 per cent of the food for the season. None were found in April, about 4 per cent in May, after which they increased to nearly 10 per cent in July, but again decreased to 4 per cent in August. Many of these are stink bugs (*Pentatomidæ*), which crawl over berries and impart a disgusting flavor to them. Others belong to the family of assassin bugs (*Reduviidæ*), which feed on other insects; but the most interesting members of this order are the scale lice (*Coccidæ*) and common plant lice (*Aphides*), two of the most destructive families of insects known. They are so minute that it seems surprising that any bird should care to eat them, but scale lice were found in eight stomachs and aphids in four. Flies (*Diptera*) make up more than 4 per cent of the food in May, and no less than 7 per cent in the single stomach taken in November. The most interesting are the larvæ of the March fly (*Bibio*), of which one stomach contained about 100. These larvæ feed on roots of grass and evidently must have been obtained from the ground. Several long-legged crane flies (*Tipulidæ*), with their eggs, were also found.

Grasshoppers and locusts were eaten in June, July, and August to the extent of 1, 11, and 17 per cent, respectively. In capturing these insects it is evident that the orioles must alight on the ground, attracted no doubt by the abundant supply and the ease with which such food can be obtained, for at this season it can hardly be supposed there is a dearth of caterpillars and other insects which they usually find on the trees. Spiders also constitute a favorite food, averaging nearly 6 per cent for the season. In May they form 5 per cent

of the food, and gradually increase to nearly 12 per cent in August. Some of the stomachs taken during the breeding season in April, May, and June contained bits of snail shells, which were probably eaten for the lime they contain.

Vegetable food of the oriole.—For its vegetable food, the oriole prefers fruit, but also eats grain and the seeds of weeds. Six kinds of fruits were found in the stomachs. Of these, cherries, raspberries, and mulberries are or may be cultivated. Cherries were identified in two stomachs, and four others contained fruit pulp too much digested for recognition. Assuming that this pulp came from cherries, six stomachs in all contained this fruit. Raspberries or blackberries were found in eleven stomachs. As this fruit is as likely to be wild as cultivated, the record does not necessarily indicate that the bird does much damage. Mulberries were found in only three stomachs, Juneberries in nine, huckleberries in one, and elder berries in one. Next to Rubus fruits (blackberries and raspberries), Juneberries seem to be preferred, and it is noteworthy that several orioles shot on or near cherry trees in bearing had no cherries in their stomachs, but some seeds of Rubus and Juneberries.

Green corn was found in one stomach and peas in two, hardly enough to establish the bird's reputation as a pilferer of fields and gardens; and as only one observer has seen it eat peas, and none corn, it may be safely said that the harm done is trifling. No traces of sprouting oats or other grain were discovered, except in one stomach, taken in April, which contained some obscure vegetable substance that may have been sprouting peas nearly digested.

If the two stomachs taken in April and the one in November are excluded, the percentage of vegetable food for the season stands about as follows: May, 7 per cent; June, 8; July, 29; August, 12. The sudden rise in July and the falling off in August are very noticeable. Moreover, in July the vegetable food consisted entirely of fruit.

While the generally harmless character of the oriole is almost universally acknowledged, a few instances of damage to fruit have been reported. It is accused of eating berries and garden peas, and several correspondents say that it injures grapes. Even John Burroughs brands it as an enemy of the vineyard, but the harm it does in this way is probably overestimated. Mr. W. F. Webster, of Oshkosh, Wis., states that it sometimes punctures grapes to suck the juice, but adds that the bird is worth its weight in gold as an insect destroyer. The stomach examinations show that it destroys immense numbers of caterpillars, grasshoppers, bugs, and noxious beetles, and does not prey to a noticeable extent on predaceous or useful beetles. Added to these good qualities, its brilliant plumage, sprightly manners, pleasing song, and skill in nest building excite our admiration. Let the farmer continue to hold his good opinion of the oriole, and accord it the protection it so well deserves.

INEFFICIENCY OF MILK SEPARATORS IN REMOVING BACTERIA.

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MILK, BUTTER, AND CHEESE AS CARRIERS OF INFECTIOUS DISEASES.

From many sources of unquestioned authority the statements have come that milk is a medium through which the contagion of many of the most destructive diseases of man and domesticated animals is sometimes disseminated. It becomes exceedingly important, therefore, that the methods which have been proposed for the destruction or elimination of the disease-producing bacteria should be thoroughly tested before they are advocated as satisfactory and efficient preventives. Certain of these processes, especially those involving the application of heat, have been tested with much satisfaction, but the efficiency of others, particularly those involving the use of electricity or the application of certain mechanical principles, has not been established. Among these it has been suggested that the treatment of milk in separators is sufficient to remove bacteria, thus rendering the cream and by-product harmless even if the milk contained obnoxious and dangerous microorganisms. While there is much evidence to refute this claim, it can not be absolutely denied without the evidence obtainable by actual experiments.

The published results of several recent investigations have shown that certain recognized dangers attending the consumption of raw milk exist, but to a less degree, in butter and cheese. In a recent number of the British Medical Journal, Rowland has called attention to these articles as carriers of typhoid fever and Asiatic cholera. Steyerthal and Konel have also pointed out several cases of these diseases which were traced to the consumption of butter. Fröhner has shown that a disease of cattle in Europe, known as foot-and-mouth disease, and which is communicable to man, has been transmitted through butter made from the milk of cows affected with that malady. It will be shown later that when the bacilli of hog cholera are placed in sweet milk they will appear in the butter and buttermilk in numbers large enough to destroy experimental animals when inoculated with small quantities of either. It has also been shown

that when certain bacteria find their way into butter they will remain alive and virulent for a considerable length of time. Lafar found tubercle bacilli alive and virulent after they had been in butter for one hundred and twenty days. Laser found the bacilli of tuberculosis, Asiatic cholera, and typhoid fever in a like condition after a week's stay in butter. An experiment[1] in this laboratory shows that tubercle bacilli will remain virulent in butter for more than ninety days.

Although the number of reported cases of infectious diseases in which the contagion was introduced through butter is not large, it is enough to show the possibility of contracting disease by the consumption of this common article of food. In view of this evidence, a careful inquiry into the character and management of milk used for this purpose is of much importance.

Up to the present time the investigations into the infectiousness of contaminated milk, and the adoption of methods whereby it may be rendered innocuous and wholesome, have been mainly in connection with human diseases. It is obvious, however, that in the rural districts the protection of milk-fed animals should not be neglected. If bacteria, such as the bacilli of typhoid fever, Asiatic cholera, and tuberculosis can contaminate milk and render it dangerous to mankind when these maladies exist on the premises where the cows are kept or where the milking utensils are handled, why can not the bacilli of hog cholera, swine plague, tuberculosis, and other specific microorganisms dangerous to domesticated animals be disseminated among them by means of the skimmed milk from creameries? In certain sections of this country this danger is recognized by the more enterprising of the farmers who refuse to use skimmed milk from creameries to feed their calves and swine unless it has been sterilized by heat. Although the preservation of human health is of the first and highest importance, the perfection of sanitary methods demands that the health and thrift of the domesticated animals, upon which mankind depend so largely for food, and which are kept in such close proximity to the human dwelling, should be likewise considered.

SIMILARITY OF ANIMAL AND HUMAN DISEASES.

Many of the animal and human diseases are found to be so closely related that it becomes impossible in many cases to omit either in a general sanitary consideration of the other. Although there are diseases which appear to be peculiar to certain species, many of the most fatal affections, such as anthrax, tuberculosis, and glanders, are communicable from animal to man, and the reverse. There are

[1] This experiment, which is being made in conjunction with Dr. C. F. Dawson, assistant in the laboratory, is not completed, but guinea pigs inoculated with a piece of butter the size of a small pea died of tuberculosis ninety-seven days after its infection. During this time the butter containing the tubercle bacilli was kept in an ice box.

others, however, such as typhoid fever of man and hog cholera among swine, which, although distinct, resemble each other so closely in the characters of their specific organisms and in the nature of the pathological changes which they produce that it seems quite probable that large quantities of the virus of hog cholera would produce ill effects in the human species, and likewise the virus of typhoid fever might, under like conditions, affect swine. The specific bacteria of these two diseases live and multiply with equal rapidity in milk, so that the danger of carrying the virus of the swine disease from farm to farm through the medium of the skimmed milk from creameries is quite as great as that of the spread of typhoid fever among the human species through the milk supply, unless some means are provided whereby these bacteria are, if present, either eliminated or destroyed.

HOW MILK BECOMES CONTAMINATED.

The foregoing statements have anticipated the important fact that milk becomes contaminated with bacteria in two ways, which, for convenience in expression, may be termed the direct and the indirect. In the direct method the contagion of the disease from which the cow is suffering is carried directly from the diseased animal into her milk. This has been found to be the case in tuberculosis where the udder is affected.[1] Heusinger has reported anthrax in man, produced by drinking the milk of a cow affected with that disease. Nocard has found anthrax bacilli in large numbers in the udder of a cow examined immediately after death. Many cases of aphthous fever are reported in man caused by the consumption of the raw milk of affected cows. Klein has stated that when milch cows are affected with diphtheria the lesions are sometimes located in the milk ducts, in which case the specific bacilli are carried directly into the milk.

In the indirect method the organisms gain access to the milk from external sources—either from the hands of the milker, the water used in washing the milk utensils, or from the dust and extraneous material which often find their way into the milk receptacles.

The assertion is frequently made by dairymen that the danger of contamination from without is overestimated, owing to the very limited number of bacteria that can gain access to the milk in this manner. The error of this assertion rests in the fact that milk is a most excellent medium for the multiplication of many species of bacteria, among which fecal bacteria and the bacilli of typhoid fever and hog cholera should be specially mentioned. Dr. Osler, in his report on

[1] There is good authority for believing that the milk of tuberculous cows, in which the udder is not diseased, sometimes temporarily contains tubercle bacilli. This fact renders the milk of all cows affected with this disease dangerous, as it is impossible to predict when bacilli will be present. This is important, owing to the fact that tuberculosis is widely distributed among cattle and that it usually reaches the advanced stages before it is recognized and the milk rejected.

typhoid fever in Baltimore, makes the following statement concerning the infection of milk:

Even when kept clean, dairies in crowded localities are exposed to very serious dangers. Milk is of all fluids the most susceptible to infection, and forms a culture medium of the very best kind, particularly for typhoid germs, which develop without altering the appearance of the milk. The dust and sweepings blown in all directions from the unwatered streets must very often contain germs which, even in any well-protected city dairy, might reach the open pans. When, however, one sees the condition of disgusting filth in which some of the cow sheds are, with heaps of manure in close proximity, the surface sewage running close by, the whole ground saturated, no adequate provision for properly scouring the pans, the cows ill nourished and dirty, the only food in many instances being distillery refuse, one can appreciate how readily under such circumstances the milk becomes contaminated. While these statements may not apply to country dairies, it is a well-known fact that many dairymen are too indifferent to the sources by which their milk may become infected.

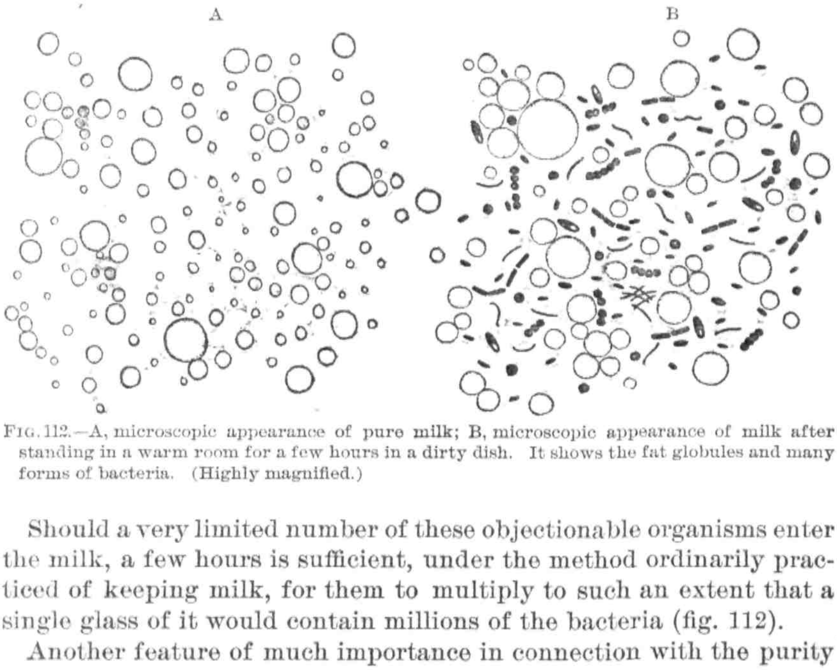

FIG. 112.—A, microscopic appearance of pure milk; B, microscopic appearance of milk after standing in a warm room for a few hours in a dirty dish. It shows the fat globules and many forms of bacteria. (Highly magnified.)

Should a very limited number of these objectionable organisms enter the milk, a few hours is sufficient, under the method ordinarily practiced of keeping milk, for them to multiply to such an extent that a single glass of it would contain millions of the bacteria (fig. 112).

Another feature of much importance in connection with the purity of milk is the view taken by medical writers that the affections of the human species traceable to milk are by no means limited to those brought about by clearly defined pathogenic bacteria. Several investigations have shown that bacteria multiply in the drop of milk left at the end of the teat, and certain of them gradually grow up into the milk ducts, from whence they are washed out in milking; so that, with the most scrupulous cleanliness, freshly drawn milk necessarily contains a considerable number of bacteria. The organisms which are invariably found in the milk ducts usually ferment milk sugar, producing acids without gas. The presence of large numbers of fecal

bacteria are likewise believed to be the cause of much sickness, especially among children. Similar dangers exist in feeding the by-products from creameries and cheese factories to domesticated animals. The literature on the etiology of animal diseases tends to show that *Bacillus coli communis* and other bacteria, ordinarily considered of a harmless nature, are, under certain conditions, capable of producing disease. It is well known that after eliminating the epizootics among animals due to recognized disease-producing bacteria we are still confronted with many outbreaks which at present can not be attributed to the invasion of recognized pathogenic organisms.

METHODS FOR DESTROYING OR REMOVING BACTERIA FROM MILK.

Without further discussion of facts already well known, we come to the important question as to how these dangers can be eliminated. To this end the united efforts of physicians, bacteriologists, and sanitarians have been directed for several years, with the happy result that means have been found by which the danger from the consumption of milk can be reduced to a minimum. This consists in sterilization or pasteurization.[1] In the latter process the objectionable bacteria are destroyed without impairing the nutritive properties of the milk.

This process, which is exceedingly simple in its application to the small quantity of milk used in private families, is more difficult when it is extended to the by-products from creameries or large dairies. In

[1] There is much confusion in the use of the terms sterilization and pasteurization. Sterilization consists in destroying all living organisms. It is usually accomplished by subjecting the material to a high temperature, 110° to 120° C. (230° to 248° F.), for a short time, by boiling for several hours, or by heating to a temperature of about 170° to 200° F. for a short time each day for several consecutive days.

Pasteurization may or may not be sterilization. The term has reference to the method used by Pasteur in 1866 for preserving wine. He found that when wine was heated to a certain temperature, about 165° F., it could be kept without the deleterious after-fermentation. About ten years later this method was used for preserving milk. When it was found that milk frequently contained disease-producing bacteria, this method was employed to destroy them. The clinical experience in using pasteurized milk taught that a temperature of 165° to 180° F. rendered it less easily digested. Then followed a long series of experiments to determine at what temperature and for how long a time it is necessary to heat the milk to destroy the pathogenic and fermenting bacteria. From these experiments it was learned that a temperature of 150° to 155° F. for one-half hour was as effective as a short exposure to 165° to 170° F. There are writers, however, who claim that 140° F. is sufficient. Pasteurization has come to mean, therefore, the destruction of disease-producing and fermenting bacteria by means of a low temperature applied for a certain length of time. If only the ordinary fermenting and pathogenic microorganisms are present, the milk thus treated would be sterilized. If spore-bearing bacteria, or those possessed of a high thermal death point, should be present, this process would not destroy them. (See article in Yearbook, Department of Agriculture, 1894, page 331.)

certain European countries much of the milk used for making butter is subjected to this process, thus eliminating the possible infectiousness of both the butter and the skimmed milk. In this country, however, methods are not generally provided whereby the consumers of butter and cheese, or the domesticated animals fed upon the by-products of their manufacture, are protected against the organisms with which the milk might have become contaminated. As already stated, a few persons in certain sections of the country, especially where infectious swine diseases are prevalent, require that the creameries sterilize their portion of the skimmed milk before it will be accepted.

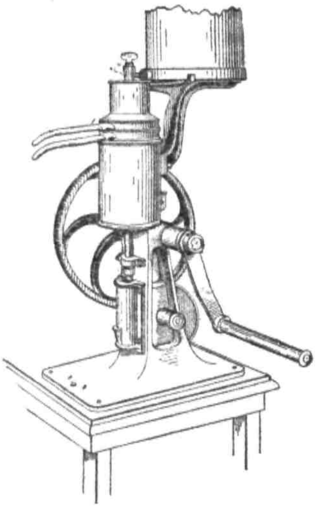

FIG. 113.—A small milk separator.

Although the various inquiries which have been made concerning milk as a carrier of disease have awakened a deep and growing interest in this subject, our people have not made a general demand for the adoption of heroic measures to check the spread of disease through the general milk supply. As a rule, in this country, it is left to each individual to use or reject the known methods of rendering innocuous milk that is possibly infectious, instead of insisting upon its being noninfectious when it leaves the dairy or the hands of the dealer.

Recently there has been a tendency to advocate the efficiency of milk separators in removing bacteria from milk and depositing them in the sediment or slime which forms on the inside of the bowl. The frequent discovery of tubercle bacilli in the slime appears to have given rise to the hypothesis that the mechanical treatment of milk in these machines is effective in eliminating the bacteria, thus rendering the skimmed milk and cream free from whatever organisms the milk formerly contained. A few experiments to determine the efficiency of this process on certain of the more important pathogenic species have already been reported. Bang has found that tubercle bacilli are very largely thrown out with the slime in milk separators. Scheurlen obtained similar results in the centrifugal machine with tubercle bacilli, but he found that other species of bacteria did not act the same under the influence of the centrifugal process. As the degree of elimination of bacteria, especially the pathogenic forms, from milk by this mechanical process measures the amount of protection against milk infection afforded to consumers of dairy products and to animals fed upon the mixed skimmed milk, the results of experiments bearing upon this subject are of great importance. The meager data obtainable prompted a series of

experiments which have been carried out in this laboratory with the specific object of determining to what extent this mechanical treatment of milk would eliminate the bacilli of tuberculosis, hog cholera, and swine plague. As it was impossible to make tests with all of the different varieties of separators, the work has been done with a single small machine (fig. 113). Directors of several creameries at State experiment stations have been consulted, and so far as I have been able to learn the mechanical treatment of the milk is practically the same in all of the separators. The results obtained are, therefore, believed to be applicable (with slight variations) to all milk separators in general use in this country. The efficiency of centrifugal machines in removing microorganisms from the cream and skimmed milk has also been tested. For this purpose a small hand machine was used.

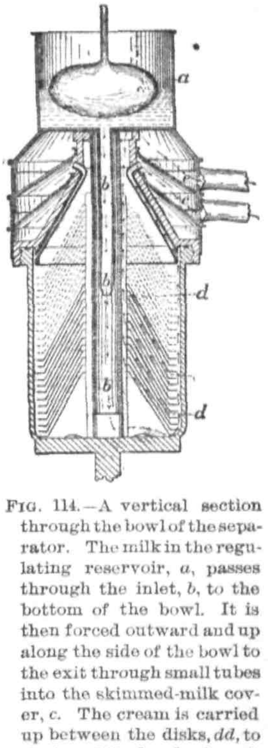

FIG. 114.—A vertical section through the bowl of the separator. The milk in the regulating reservoir, *a*, passes through the inlet, *b*, to the bottom of the bowl. It is then forced outward and up along the side of the bowl to the exit through small tubes into the skimmed-milk cover, *c*. The cream is carried up between the disks, *dd*, to the top of the bowl, where it escapes through a groove into the cream cover.

EXPERIMENTS WITH THE MILK SEPARATOR.

A.—ON THE REMOVAL OF TUBERCLE BACILLI FROM MILK.

While it is not intended to give in detail the various technical steps in these investigations, it is necessary to indicate some of the more important points concerning the methods employed.

As it was impracticable, if not impossible, to obtain milch cows so affected with tuberculosis of the udder that the tubercle bacilli were given off in large numbers, it became necessary to use milk artificially infected with these organisms. Much difficulty was experienced in evenly distributing these bacilli throughout the milk on account of their tendency to hang together in clumps when grown in glycerinated bouillon or on blood serum. This was largely overcome, however, by grinding the growth of tubercle bacilli taken from cultures in sharp sand. Before using, the sand was thoroughly washed in water, treated for some minutes with hydrochloric acid, and again washed repeatedly in water. After grinding the growth from artificial cultures for about one-half hour with a pestle in a mortar, a few cubic centimeters of sterilized bouillon were added, and after several minutes of stirring the suspension was filtered through a layer of cotton, which removed the sand and larger clumps of bacilli, but permitted the very small clumps and single bacilli to pass through. This method gave satisfactory and uniform results. A microscopic examination of properly

stained cover-glass preparations showed that in a drop of the suspension thus prepared there were many tubercle bacilli. Definite quantities of this suspension were added to known amounts of fresh milk and thoroughly mixed by pouring repeatedly from one jar to another. The milk was then passed through the separator, which was run at the rate of 7,200 revolutions per minute.

In the first experiment 7 c. c. (about 2 teaspoonfuls) of the suspension of tubercle bacilli were added to 4,000 c. c. (over 1 gallon) of fresh milk. The microscopic examination of the milk, after the suspension was added and thoroughly mixed, showed tubercle bacilli (fig. 115) in small numbers in about 30 per cent of the preparations examined. After the milk had passed through the separator, tubercle bacilli were not found by the microscopic examination in the skimmed milk, cream, or in the milk left in the bowl of the separator, but a similar examination of the scrapings or slime from the side of the bowl showed a considerable number of them. They were single and in small clumps.

FIG. 115.—A, milk containing tubercle bacilli; B, tubercle bacilli from a serum culture.

Judging from the results of the microscopic examination, it seemed that the separator had completely removed these bacilli from the milk and cream and concentrated them in the sediment or slime which was formed on the inside of the bowl, a result similar to that obtained by Bang and other European investigators. Although the results were apparently conclusive, a search for tubercle bacilli in milk by means of the microscope alone can not be considered final, as at most only a very small percentage of the milk or cream could ordinarily be actually examined. This uncertainty is intensified when the number of bacilli originally in the milk is small. In order to verify the accuracy of the results obtained in this experiment, therefore, further and more rigorous tests were necessary. Unfortunately, in the first experiment, cultures of an attenuated bacillus were used, so that inoculations or feeding experiments would have availed nothing in establishing the accuracy of the conclusion naturally drawn from the microscopic examination. A test approximating the actual practice of farmers who feed swine and calves on skimmed milk from creameries, namely, feeding guinea pigs or other small animals with large quantities of milk thus treated, suggested itself. The possibility, however, that a small number of these organisms would either be

destroyed in the stomach or pass through the intestinal tract without injury to the animal, rendered the inoculation of these animals with definite quantities of the milk and cream the surer method of making this determination, especially as guinea pigs react promptly to very small numbers of virulent tubercle bacilli when they are injected either under the skin or into the peritoneal cavity. The experiment was repeated with milk to which virulent tubercle bacilli had been added, and guinea pigs were inoculated with definite quantities of the skimmed milk and cream.

In the second test a smaller quantity, 2,900 c. c. (about 3 quarts), of milk was used, but otherwise the conditions and treatment of the milk were the same as those in the first trial.

March 29 two guinea pigs (Nos. 367 and 368) were inoculated in the peritoneal cavity with 3 c. c. each of the skimmed milk, and two others (Nos. 369 and 370) with a like quantity of the cream. These died of tuberculosis on the following dates:

Guinea pig No. 367 died April 30, 1895, thirty-one days after inoculation.
Guinea pig No. 368 died April 22, 1895, twenty-four days after inoculation.
Guinea pig No. 369 died May 2, 1895, thirty-four days after inoculation.
Guinea pig No. 370 died May 18, 1895, fifty days after inoculation.

These inoculations demonstrated the passage of the tubercle bacilli into the cream and skimmed milk. From the large number of bacilli found in the sediment upon microscopic examination, it seemed that most of them were deposited in the slime on the inside of the bowl. The fact, however, that the animals died of tuberculosis is enough to demonstrate the infectiousness of the skimmed milk and cream.

Ostertag has called attention to the fact that there is much tuberculosis among swine in certain parts of northern Germany, where they are fed upon the slime from the large separators used in creameries.

The results of these experiments correspond with those elsewhere reported where comparatively few tubercle bacilli were in the milk. It sometimes happens that milk from tuberculous cows contains many more bacilli, as indicated by the microscopic examination, than the artificially infected milk used in the two preceding experiments. In the mixed milk, however, the number of tubercle bacilli is rarely if ever as large as it was in the infected milk used in these tests. To ascertain the efficiency of this process in eliminating these organisms when they are present in large numbers, as in instances where the milk from a single cow suffering with tuberculosis of the udder is used, a third experiment was carried out in which a much larger quantity of the suspension of the tubercle bacilli was added. The infected milk was treated as before, after which careful microscopic examinations were made. In 16 per cent of the preparations of the skimmed milk, and in all of those from the cream, tubercle bacilli were found. They were more numerous in the preparations made from the cream than in those from the milk. This fact affords a reasonable explanation

for the statement that tubercle bacilli are frequently found in butter. As in the other experiments, the slime contained the bacilli in much larger numbers than the skimmed milk or cream.

It is claimed for certain separators that the rapidity with which their bowls revolve adds to their efficiency in removing bacteria. In order to determine whether or not this condition would diminish the number of tubercle bacilli in the skimmed milk and cream, a test was made in which the number of revolutions of the bowl was increased at least one-half over that in the preceding experiments. The result was practically the same.

It is of interest to add that in all of the experiments the microscopic examinations showed that the dense clumps of bacilli were for the greater part deposited in the slime, while single bacilli and those in loose masses were found in the cream. It is probable that the mechanical forces involved tend to throw the bacteria to the sides of the bowl, but that many of them are arrested in their outward course and carried to the top on the surface of the fat globules. The upward current of the milk (fig. 114) would likewise tend to carry the bacteria into the skimmed milk.

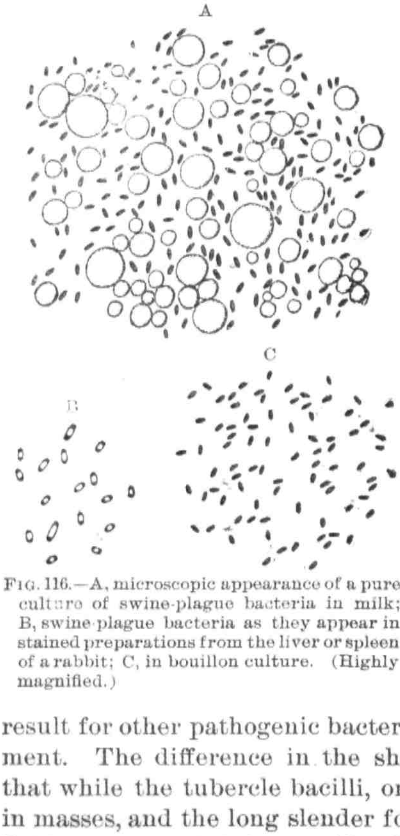

FIG. 116.—A, microscopic appearance of a pure culture of swine-plague bacteria in milk; B, swine plague bacteria as they appear in stained preparations from the liver or spleen of a rabbit; C, in bouillon culture. (Highly magnified.)

B.—INEFFICIENCY IN REMOVING SWINE-PLAGUE AND HOG-CHOLERA BACTERIA.

Although tubercle bacilli will pass in appreciable numbers through the separator and appear in the skimmed milk and cream, it is impossible to predict the same result for other pathogenic bacteria when subjected to the same treatment. The difference in the shape of the bacteria would indicate that while the tubercle bacilli, on account of their tendency to grow in masses, and the long slender form of the individual organisms, are liable to be carried in considerable numbers to the surface with the fat globules, shorter organisms might follow the centrifugal influences without being intercepted on their way. To determine this point, experiments were made with the bacilli of swine plague and hog cholera.

About 100 c. c. of a twenty-four-hour bouillon culture of virulent swine-plague bacteria (fig. 116) were thoroughly mixed with 4,000 c. c.

of fresh milk, after which it was immediately passed through the separator. Cover-glass preparations were made and carefully examined from the cream, milk, and sediment on the inside of the bowl. Each of them showed a very large number of bacteria. As the milk itself at the time it was used contained a large number of bacteria which could not be positively differentiated by the microscopic examination from the swine-plague bacillus, it was necessary to inoculate rabbits in order to determine whether or not this bacillus was present in the skimmed milk and cream. Accordingly, a rabbit was injected subcutaneously with 0.1 c. c. of the skimmed milk and another with a like quantity of the cream. Both of the rabbits died of swine plague within twenty-four hours.

A similar experiment was made with a culture of the bacillus of hog cholera (fig. 117). The rabbits in this case were inoculated with 0.25 c. c. of the milk and cream, respectively. They died of hog cholera on the seventh day, the time death would have been expected had the rabbits received 0.1 c. c. of a pure bouillon culture.

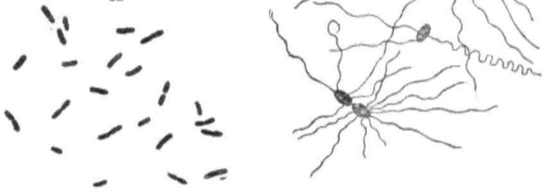

FIG. 117.—A, hog-cholera bacilli as they appear in ordinarily stained preparations from cultures; B, when stained in a special manner, showing their flagella. (Highly magnified.)

EXPERIMENTS WITH THE HAND CENTRIFUGAL MACHINE.

Scheurlen[1] found that bacteria acted differently under the influence of this process. Anthrax bacilli (fig. 118) and their spores, the bacilli of typhoid fever (fig. 119) and Asiatic cholera were gathered in the cream, while tubercle bacilli were for the greater part thrown down. The writer has made several tests with tubercle bacilli with somewhat different results. Similar experiments with bacteria of hog cholera and swine plague have shown that they, too, are not all thrown to the bottom of the tubes, as the appended notes will show.

Milk containing tubercle bacilli[2] was treated in the centrifugal machine, running at the rate of 1,600 revolutions per minute for eighteen minutes. Cover-glass preparations were made from the milk before passing through the centrifugal machine, and from the milk, cream, and sediment after such treatment. Six preparations from each were carefully examined, with the following results:

Milk before treating.—Each preparation contained five or more tubercle bacilli.

[1] Arbeiten aus dem Kaiserl. Gesundheitsamte, VII (1891), 269.

[2] Definite quantities of a suspension of tubercle bacilli in bouillon, prepared in the manner described on p. 437, were added to the milk.

Cream.—Five preparations contained from one to five single bacilli or clumps. In one preparation they were not found.

Skimmed milk.—Two preparations contained very few tubercle bacilli. In four tubercle bacilli could not be found.

Sediment.—Two of the six preparations contained many tubercle bacilli; two contained very few, and in two these bacilli could not be found.

FIG. 118.—Bacilli of anthrax. A, without spores; B, with spores. (Highly magnified.)

These experiments were twice repeated, with similar results.

In testing the behavior of hog-cholera bacillus when subjected to this treatment, 150 c. c. of fresh milk was taken, to which 5 c. c. of a twenty-four-hour bouillon culture of the hog-cholera bacillus was added, and thoroughly mixed. The mixture was treated in the centrifugal machine for twenty minutes, running at 1,600 revolutions per minute. Cover-glass preparations were made from the cream, central layer of the milk, and sediment, and examined microscopically. Many bacteria were found in each, although the number in the sediment was appreciably larger than in the milk and cream. As there was a large number of bacteria in the milk from which it was impossible to differentiate the hog-cholera bacteria by the microscopic examination alone, rabbits were inoculated subcutaneously with a small quantity (0.2 c. c.) of the milk and cream. The quantity injected was so small that the dose would have been incapable of producing rapidly fatal results if a large percentage of the hog-cholera bacteria had been deposited in the sediment. The inoculated rabbits died on the seventh day, with lesions characteristic of hog cholera.

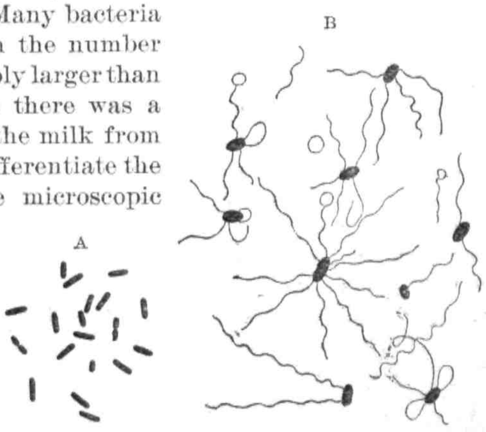

FIG. 119.—A, bacilli of typhoid fever; B, the same stained by a special method showing their flagella. (Highly magnified.)

This experiment was very carefully repeated, with the same results.

Similar experiments were made with the swine-plague bacteria, with the result that experimental animals, when inoculated subcutaneously with very small quantities of the cream and milk, died of swine plague within twenty-four hours.

A large number of experiments in removing the bacteria ordinarily found in milk were made with both the centrifugal machine and the milk separator. The milk used contained a large number of bacteria. Plate cultures made with like quantities of the untreated milk, the skimmed milk, and cream, developed practically the same number of colonies, showing conclusively that the process of separation was inefficient in removing the bacteria ordinarily present in milk.

The results of the experiments recorded in the preceding pages show that the physical conditions involved in the mechanical treatment of milk do not allow the deposition of all bacteria in the sediment. Many of the bacteria were carried over into the skimmed milk and into the cream. With this fact before us it is easy to understand that the butter made by the use of the separator from infected milk might contain the specific bacteria. This was illustrated by the following experiment with the hog-cholera bacillus.

A quantity of fresh milk was obtained and a few cubic centimeters of a bouillon culture of the bacillus of hog cholera were added and thoroughly mixed with it, as in the preceding experiment. The milk was then passed through the separator and the cream collected in a sterile beaker, and allowed to stand in the laboratory until ripe, when it was churned. The butter was carefully worked, washed, salted, and placed in an ice box. The buttermilk was preserved in a sterilized jar, but kept at the room temperature. Four days afterwards a rabbit was inoculated beneath the skin with 0.2 c. c. of the buttermilk, and another with a piece of the butter about the size of a pea. These rabbits died of hog cholera in seven days. These experiments confirm the opinion of many farmers that unsterilized mixed skimmed milk from creameries in those sections of the country having outbreaks of infectious swine diseases, or where there is much tuberculosis among the cattle, is not safe for feeding calves and swine.

In Denmark the skimmed milk in creameries, when not used for making cheese, is heated to a temperature near the boiling point. This permits the return of all the milk without souring, and it also destroys all bacteria with which the milk may be contaminated. It is stated that the farmers in that country recognize the danger of mixed milk coming from many sources, and refuse to use it, before it is sterilized, in their households or for feeding their animals. In this country the necessity for such precautionary measures is quite as great, but it is not so generally recognized.

HOW TO ELIMINATE THE DANGERS.

With our present knowledge of the possible infectiousness of milk, the question very naturally presents itself, How can these impending dangers be eliminated? To this the answer is not difficult. The recognized efficiency of the milk separators now in use indicates that from the butter-making standpoint a radical change is not necessary.

From the experiments mentioned above we can not expect that separators will remove, to a sufficient extent, the bacteria which the milk may contain. This being the case, we must look for methods whereby the bacteria, especially the fermenting and pathogenic forms, if present, can be destroyed. The simplest and most effective of those known at the present time is the application of heat, either pasteurization or sterilization. Pasteurization could be applied to the milk, rendering the cream and butter as well as the skimmed milk free from infection. If the skimmed milk only were heated, the danger of its spreading infectious diseases among animals would be removed. Furthermore, it could be taken from the creameries to the farms of the patrons in a wholesome condition, thus avoiding many of the intestinal troubles of calves and swine attributed to feeding them the fermented skimmed milk. The expense of the necessary apparatus[1] for creamery use would be comparatively slight, a mere trifle compared with the benefit to be derived from the improved condition of the skimmed milk.

In considering the obnoxious bacteria in milk, the fact must not be overlooked that this fluid contains many bacteria which are not known to be harmful, and sometimes others whose presence is much to be desired. It is now known that the delicate flavors of the choicest butters are due to the presence of certain species of bacteria in the milk. In a few creameries it is said that the milk is inoculated with these bacteria in order to assure the desired flavor of the product. Recognizing this, the necessity for pasteurizing milk is quite as apparent from the butter-making stand point as it is from the sanitary side, as it would destroy all fermenting and other undesirable bacteria which might otherwise interfere with the organisms subsequently introduced to impart to the butter the particular flavor desired.

The farmer should recognize the danger to which he subjects his animals when he feeds them with milk coming from dairies in which there are tuberculous cows, or which are on farms where infectious diseases, liable to be carried in the milk, exist. If the enormous losses annually sustained from animal diseases are to be reduced, it is imperative that every interested individual should adopt such precautionary measures as have been demonstrated to be efficient. By pasteurizing or sterilizing milk in creameries, one of the channels through which domesticated animals are liable to become infected would be closed.

[1] For a description of the various appliances for pasteurizing and sterilizing milk in large quantities, see article by Dr. E. A. de Schweinitz, Yearbook of Department of Agriculture, 1894, p. 331.

BUTTER SUBSTITUTES.

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MANUFACTURE AND SALE OF OLEOMARGARINE.

In 1869 Mege Mouries, at the instigation of the French Government, undertook experiments for the purpose of securing a substitute for butter which could be produced at less cost and might be used by the navy and by the poorer classes of citizens. This original process was patented in the United States in 1873. Without giving Mege Mouries's patent in detail, the principal points were the preparation of margarine oil by the artificial digestion of the fat taken from animals and the separation of the stearin, which melts at a high temperature, by pressure. This so-called liquid margarine was then churned into milk, finely divided cow's udder and carbonate of sodium being used to facilitate the emulsion. The result was a product which when salted and colored resembled butter in appearance, taste, and general properties. Many modifications of this process were at once suggested, the object being to utilize as much as possible surplus animal fats. For this purpose numerous improvements were patented for purifying these fats by fermentation and by the subsequent use of chemicals.

The process as at present used, however, is comparatively simple. The oleo oil and "neutral" lard are mixed together, either alone or with the addition of cotton-seed oil or milk and butter, in steam-jacketed vessels provided with paddles, the resulting product being called oleomargarine or butterine, according to the quantity of butter used. The manufacture is a simple one, and the questions of importance are the character of the fats used and the cleanliness in the preparation of the oleomargarine.

The two especial points originally claimed for the oleomargarine were, that by a judicious admixture of stearin the product would retain its consistency, even in hot weather, and that it could be readily transported and preserved for a long time without becoming rancid. For cooking purposes the oleomargarine should be quite useful, as it

is simply the mixture of the natural animal fat in such proportions as to produce a compound having the consistency of butter; but for eating in place of butter—an article of food which is made more palatable and digestible by its particular aroma and flavor—the results are different. This fact was recognized and acknowledged as soon as its use was begun. As the oleomargarine could be made very much more cheaply than butter, fraud was at once inaugurated by selling the product as pure butter. The development of this traffic was not in response to a public demand, but the product was brought to the public under the guise of genuine butter, so that a continuous fraud was perpetrated. The enormous abuses in this traffic led to the adoption of very stringent laws, on the part of many States, with reference to the manufacture and sale of oleomargarine. On this account its manufacture is at present confined to eight States, there being, according to the report of the Commissioner of Internal Revenue, August 10, 1895, five factories in Illinois, two in Indiana, three in Kansas City, Mo., and Kans., one in Nebraska, one in Ohio, one in Pennsylvania, and four in Rhode Island.

In the year 1883, 45,000,000 pounds of oleomargarine were sold in the United States, and in spite of restrictive legislation the manufacture has slowly increased; in 1894, 69,622,246 pounds were manufactured, against 67,224,298 pounds in 1893, an increase of 2,397,948 pounds. The amount withdrawn for export for the fiscal year 1893 was 2,785,494 pounds, and for 1894, 3,406,683 pounds, showing a slight increase in the export trade, but not proportional to the increased manufacture.

MATERIAL USED FOR MANUFACTURE.

In the Eastern States the larger part of the oleo oil and lard used in the manufacture is purchased, while in the Western factories the materials used are prepared directly in the oleomargarine factories. To prepare oleo oil, the chief product, the selected and ground animal fats, are melted in kettles at as near 150° F. as possible, and the fiber allowed to settle out. The melted fat is then run into chilling vats, where it is cooled until most of the stearin has crystallized. The mixture is then thoroughly pressed, the olein, together with a little stearin and palmitin, constituting the oleo oil, while the remaining press cake, consisting of stearin, is used in the manufacture of soap, candles, compound lard, etc. The amount of pressure used in separating the stearin is varied at times, leaving a greater or less quantity of stearin in the oleo oil.

The fat which is used especially for preparing the oleo oil is that cut from the kidneys and intestines. In the large packing houses, where the manufacture of the oleomargarine is carefully conducted, only the best selected fats are used. As a matter of fact, only clean, fresh fat can be utilized in preparing a really good product. In the

smaller factories, however, which are devoted to the manufacture of oleomargarine alone, the oleo oil is rendered from the scraps of the abattoirs, butcher shops, and sometimes from hotel waste. These scraps necessarily include not only the fat of beeves, but of sheep, hogs, chickens, etc.—anything, in fact, which may find its way into the butcher shops. The fat scraps when brought to the factory are first carefully sorted, and washed in large vats. Pieces that have a slightly tainted odor are thrown out, to be used for the manufacture of tallow or for the soap makers. The good pieces are then cut up and ground and used for the preparation of the oleo oil.

The lard used for oleomargarine is usually good leaf lard. The cotton-seed oil used in the manufacture of oleomargarine is probably the most healthful of all its constituents, as generally a good quality is selected.

The proportions in which the oleo oil lard and cotton-seed oil are mixed vary with the season of the year and the character of the products desired. Some manufacturers do not use cotton-seed oil. For the manufacture of butterine, butter, usually of a very good grade, is *churned in with the oleo and lard to secure the flavor*, while the desired color is obtained by the addition of annatto and turmeric. The oleomargarine proper is made without butter, and is colored to suit the requirements of the trade. The export trade seems to demand a very highly colored product; a brand of a tomato color is in high favor in the West Indies and Central America.

HYGIENIC EFFECTS OF OLEOMARGARINE.

The important points in connection with oleomargarine are its hygienic effects as compared with butter. First, as to its digestibility. Very few careful and systematic experiments as to the actual digestibility by man of oleomargarine as compared with butter have ever been made. Mayer, a German chemist, reports two series of experiments conducted, one upon a man, the other upon a boy, which showed the digestibility of oleomargarine to be about 2 per cent less than that of butter. A number of prominent chemists have placed themselves on record as holding that oleomargarine, if properly and carefully made from good, fresh fat, was quite as healthy and digestible as butter. With the exception of the experiments reported, none of these gentlemen, however, had made any practical tests as to the digestibility of these fats, but based their opinions entirely upon theoretical considerations.

Within the last few years the process of manufacture has changed considerably, so that the results as to digestibility would now differ materially from those of the early experiments. All the statements in regard to its use, however, are qualified with the proviso that these products are good if made from fresh and healthy material.

Sell, the authority on foods for the German Government, says:

Apart from a somewhat less digestibility, the artificial butter prepared from the fat of healthy animals furnishes in general no reason to suppose that it can affect the health injuriously. There is good ground, however, to believe that a part of the artificial butter is manufactured from fat of diseased animals, or dead animals, and often from material that will have to be deodorized.

A committee of the Academy of Medicine in Paris, in 1880, after studying the subject, declared that oleomargarine was not as digestible as butter, on account of the larger amount of stearin and palmitin, but, unfortunately, they did not give the experiments leading to these conclusions.

To establish some data in this connection, A. Jolles, of Vienna, has recently conducted an experiment upon a dog, feeding the animal during two periods of eight days each with the best butter, and during two other periods of eight days each with oleomargarine, together with sugar, wheat meal, and salt. The analysis of the butter showed—

	Per cent.
Water	10.24
Casein	.63
Milk sugar	.54
Salts	.34
Fat by difference	88.25
Total	100.00

Reichert No. 28.6.

The analysis of the oleomargarine showed—

Iodine No	47.0
Melting point fatty acid	42.6° C.
Solidification point	39.5° C.
Saponification equivalent	197.5

The butter was obtained from a Vienna dairy and very carefully made. The oleomargarine was also from a specially prepared lot made by the Vienna Margarine Company. The experiment was carefully conducted. Exact analyses of the constituents of the food used were made, the quantity consumed carefully weighed and the excreta also carefully weighed and analyzed, so as to show the quantity and character of the material actually absorbed. From these data the results were calculated, and the conclusion drawn that under exactly the same conditions the oleomargarine, if perfectly pure, was quite as digestible as the butter. The quality of perfect purity, however, and a sample of the same character as that used by Jolles would be difficult to obtain, certainly can not be found in our markets, if the samples we have examined serve for good comparison. And, it may be added, fats which are equally digestible, and which would not affect digestion in the dog, might show an important difference when taken into the

stomachs of people whose digestion under most favorable conditions is not satisfactory.

As fat is one of the most important factors in the production of animal heat, the heat of combustion of butter and oleomargarine should throw some light on their relative value. The calories of 1 gram of butter fat are about 300 less than of 1 gram of oleomargarine, showing that more heat is given by the oleomargarine. This also indicates, however, a more complex fat molecule, and probably less digestibility for the oleomargarine.

There are a number of interesting cases where dissatisfaction can be traced to the use of oleomargarine. This product was furnished to the inmates of a certain blind asylum without their knowing its character. They ate less and less every day, and finally altogether refused to use it, saying that it was undesirable. This was the natural rebellion on the part of the digestive organs to the use of a mixture of fats which was not adapted for the purpose to which it was applied. While recently engaged in an examination of samples of oleomargarine, an employee of the Bureau biochemic laboratory undertook to substitute a good brand of oleomargarine for butter at his meals. After a few days he claimed that this had caused indigestion, and he would not use it any longer.

Without entering upon a discussion of the process of digestion in the animal body, the action of the pancreatin appears to be most important in the emulsification of fats. An artificial digestion, imitating as nearly as possible the conditions obtaining in man, shows that butter is far better emulsified than either cotton-seed oil, oleomargarine, or suet, and consequently more rapidly digested. The undesirability of oleomargarine is proved again by the fact that in hotels, boarding schools, and public institutions where oleomargarine and butterine are furnished instead of butter there is less used.

POSSIBILITY OF TRANSMITTING INFECTIOUS DISEASES.

The point next to be considered is the possibility of the transmission of infectious diseases by oleomargarine made from impure materials. That such can occur is undoubtedly true. A comparison of the germs present in oleomargarine and butter showed three times as many in the one as in the other, with a difference in the character of the germs. The germs in the butter were the harmless ones found in milk and necessary for the production of a good butter. Those in the oleomargarine were fungi and numerous varieties of bacteria.

The writer has made a number of inoculation experiments upon guinea pigs with different samples of oleomargarine. The samples were purchased in open market, near the places where they were manufactured. Sample No. 3 (102) proved fatal, causing the death of the animal in the one instance in two months; in the other, in two weeks. An examination showed the lungs congested, the liver soft

and pale, one of the kidneys badly congested, and five distinct ulcers in the intestines, like typhoid-fever ulcers. The bladder was distended and urine albuminous. At the present writing the nature of this disease has not been determined, but the fatal effects were produced by the oleomargarine. Another guinea pig inoculated with a sample (No. 1) of oleo oil, taken from a lot used in the manufacture of oleomargarine, died within three weeks, the autopsy showing badly congested lungs, liver dark, blood vessels congested, and the small intestines containing bloody mucus.

Five months after inoculation with another sample (No. 6 I) (105) of oleomargarine the pig which had been used for the experiment was chloroformed for examination. The animal was in fair condition, but the left lung showed incipient tuberculosis, and this disease was also apparent in the spleen, and there were several calcareous tubercular nodules adherent to the sternum. A preparation made from this same sample had shown the presence of a germ which could scarcely be anything but the tuberculosis bacillus. The result of the inoculation confirmed this diagnosis. The inoculations of all the animals were made by introducing in the side a bit of fat the size of a small pea. The incision healed rapidly, and at the time of the autopsies there was no evidence of local lesions or any effect which might have been due directly to the mechanical part of the inoculations.[1]

A number of other guinea pigs have been inoculated with different samples of oleomargarine, but at this writing (after eight months) have not contracted disease from the oleomargarine inoculation. Two of the samples which caused disease in the animals were made at a factory where the material used may have been questionable in character.

Our inoculation experiments show conclusively that disease may be communicated by means of oleomargarine. The objection might be raised that disease could also be communicated in the same way by butter. It is, however, a very simple and easy matter to pasteurize the cream before churning, and use some of the known good butter-flavoring bacteria to develop the aroma; or it might be possible also to flavor the butter with the volatile acids and ethers which the bacteria produce. In this way butter can be easily made which is perfectly harmless, even supposing, what has not been proved in this country, that good butter could serve as a source of disease. The temperature of pasteurization is, however, unfavorable for oleo-oil manufacture.

Another point often urged in favor of oleomargarine is that it will keep longer than butter without becoming rancid. Of course, tallow,

[1]Two other animals that had been inoculated with oleomargarine (No. 4 I and No. 2 III) (103 and 107) were also found dead. One showed evidences of incipient tuberculosis; the other, digestive derangement.

stearin, and lard will keep longer than butter without spoiling, but there is no object in using plain oleomargarine, as one might as well at once spread stearin and lard on the bread. Butterine which contains a considerable amount of butter will become rancid almost as readily as butter. Good butter, if carefully made and well washed, will keep satisfactorily.

The statements of most authorities have been to the effect that oleomargarine is good and digestible and healthful, provided it is made from pure material and the process is properly conducted. The legitimate and safe manufacture of oleomargarine can be secured, therefore, only when there is careful and safe control and inspection at the abattoirs and oleomargarine factories of both the finished product and the constituents which enter into its manufacture. Then, too, all the oleomargarine should be sold as oleomargarine, and should have something distinctive about its appearance—absence of color, as Massachusetts demands, or a specially bright color; and every pound of it should be carefully inspected at the factories before being shipped, to see that the particular distinctive character is present.

FRAUDULENT SALE OF OLEOMARGARINE.

Another frequent and serious objection that can be used against oleomargarine is the fact that its sale is usually fraudulent, as the article is not sold under its true name. Recently several butter samples were purchased in the open market of Washington City, by a butter dealer, as the best varieties of butter that could be obtained, and submitted to this laboratory for examination. Only one of these was found to be butter.

In some of the States the laws are very stringent against the fraudulent sale of oleomargarine, and heavy penalties are provided for its evasion. In Massachusetts it is against the law to sell oleomargarine which has been colored. This lack of color renders it possible, as a rule, to distinguish between oleomargarine and butter. In Pennsylvania the law forbids the sale within the State of oleomargarine manufactured in the State, but that manufactured outside of the State can be sold within its borders. In spite of this restrictive legislation, however, the production of oleomargarine, as shown by the figures before quoted, is steadily increasing.

To show the comparative composition of oleomargarine of various sources and good butter, the following table is given:

Analyses of oleomargarines, butterines, and butters (by James A. Emery).

OLEOMARGARINES AND BUTTERINES.

Serial number.	Water.	Casein (albuminoid).	Ash.	Salt.	Volatile fat acids (No. cc. $\frac{n}{10}$ $Ba(OH)_2$ to 2.5 gr.).	Iodine number.	Specific gravity.	Melting point.	Combustion (calories per gram).	Cotton-seed oil.
								° C.		
100	8.09	1.46	4.24	4.02	0.30	62.19	0.8916	......	....	
101	9.68	1.43	4.68	2.30	.17	63.52	.8638	......	....	
102	10.96	1.56	6.01	6.60	.25	66.69	.8667	......	....	
103	9.32	.07	......	4.80	.15	61.44	.8913	......	....	
104	9.40	4.83	......	5.40	.17	62.83	.8848	25.0	....	
105	9.86	.48	......	6.80	.20	63.26	.8911	25.5	....	
107	8.52	1.41	4.77	4.43	.55	59.11	.8808	24.0	....	None.
108	8.53	1.36	5.95	5.17	.42	52.80	.8835	23.0	9.599	Considerable.
110	7.37	1.16	......	6.18	.35	63.12	.8834	24.5	....	Do.
112	6.86	1.77	......	3.72	.42	58.57	.8914	22.5	....	None.
113	9.47	1.33	5.67	5.31	.35	66.50	.8828	25.0	9.795	Considerable.
115	9.00	1.66	3.68	3.68	.30	66.59	.8874	22.5	9.649	Do.
118	9.15	1.43	6.21	6.69	.22	60.53	.8891	25.0	9.607	None.
119	9.25	.77	4.00	4.04	.26	53.37	.8876	26.5	9.574	Do.
120	9.87	2.64	5.70	5.22	.82	58.12	.8818	25.5	9.613	
121	9.23	1.52	3.68	3.80	.35	61.80	.8880	22.5	9.670	None.
124	9.37	1.63	5.42	5.82	.22	64.66	.8898	23.5	9.615	Do.

BUTTERS.

125	8.32	1.27	3.64	3.81	11.10	37.75	.8925	35.5	9.327	None.
126	11.43	1.83	4.98	4.05	8.55	36.86	.8979	36.1	9.362	
127	12.98	1.30	3.94	4.04	10.82	41.20	.8984	35.5	....	

As will be seen at a glance, the melting points of the oleomargarines are low. The samples were purchased in the spring; some contained considerable cotton-seed oil, and were evidently made for the winter trade. A product intended for summer use would contain more stearin. The minute quantity of volatile acids shows the presence of only a trace of butter, or its entire absence, while the high iodine absorption shows the presence of considerable cotton-seed oil or lard.

The figures in some of the samples for albuminoids show an unusually high percentage. This points to a contamination with animal fiber and indicates that the material used was not pure.

THE MANUFACTURE AND CONSUMPTION OF CHEESE.

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GROWTH OF THE INDUSTRY.

Cheese making is not a conspicuous industry in the United States, yet it is a considerable one, cheese being an important article of trade, domestic and foreign. In the early part of the present century, cheese was the principal product on many dairy farms in the Eastern and Middle States. It accumulated on the farms and was moved to market only once or twice a year, then creating quite a stir in certain centers of traffic. Exports of cheese from America began more than a hundred years ago, and in the year 1800 the quantity had reached nearly a million pounds. Production and export then grew quite steadily, both increasing rapidly at times, until about fifteen years ago. The total cheese production of the country was reported for the census years of the last five decades as follows:

	Pounds.
1849	105,535,893
1859	103,663,927
1869	162,927,382
1879	243,157,850
1889	256,761,883

The relation of these figures is shown by the following diagram, where the entire surface of each rectangle represents the production of the year stated, and these surfaces compared indicate the increase from decade to decade:

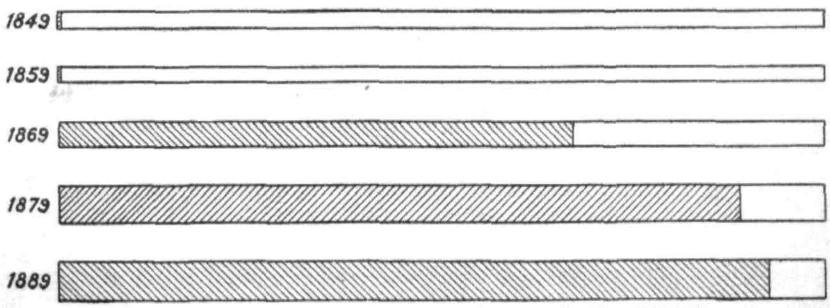

FIG. 120.—Diagram showing increase in cheese production, 1849-1889.

This diagram also shows graphically the great change in the system of making cheese, which has taken place during the last half century. The shaded portion of each rectangle represents the cheese made in factories, and the unshaded part that which was made on farms.

Prior to 1850, practically all of the cheese of this country was made on the farms where the milk for it was produced; it was simply an article of domestic manufacture. About the year 1860 the cheese factory came into vogue as an improved and economical system for cheese making. Wherever the idea may have actually originated, it was first fixed upon the public mind and developed in the county of Oneida, New York. Once established, the advantages of the associated method became manifest, and the spread of the "American," or "factory," system was very rapid. So much so that in 1869, two-thirds of the cheese of the country was made in factories. The proportion of cheese now made on American farms is insignificant, compared with that made in factories.

At the present time it requires the entire milk of nearly 1,000,000 cows to make the cheese annually pressed in the United States. This is based upon an annual yield of about 2,800 pounds of milk from a cow, on an average, with a rate of 10 pounds of milk to a pound of cheese. At 9 to 10 cents per pound, the average value of cheese per cow is not over $27 *per annum* (a little more than the value of the average cow), and the total product of the country is worth from $24,000,000 to $25,000,000. These figures are only approximately correct. To the annual cheese product of the United States, 260,000,000 pounds, may be added 9,000,000 pounds of imported cheese, and 76,000,000 pounds being exported, leaves something less than 200,000,000 pounds yearly consumed by the people of this country. The rate of consumption here is therefore about 3 pounds of cheese per capita of the entire population. In some districts where the supply is abundant and of good quality, there is reason to believe that the maximum rate of cheese consumption for well-to-do communities is 7 to 9 pounds per annum, or about 40 pounds for the family of average size.

Nine-tenths of the cheese produced in this country is made in the States of New York, Wisconsin, Ohio, Illinois, Vermont, Iowa, Pennsylvania, and Michigan. These rank as to production in the order named, and no other State produces over 5,000,000 pounds a year. The last four States named produce 5,000,000 to 6,000,000 pounds each, and the others from 10,000,000, for Illinois, up to 124,000,000, for New York. The New York product alone is almost one-half, and this State and Wisconsin together make over two-thirds, of the total of the country. There have been a good many changes in relative production in recent years, Ohio, Illinois, and Pennsylvania having decreased their annual cheese product from one-third to one-half since the census of 1880.

For a long time New York State cheese held first place in reputation and market prices, but Wisconsin rose to an equal position in 1878, and maintained it, excepting for a few years, when the manufacture of imitation or lard cheese in this State was so largely carried

on as to greatly injure this reputation. State law having prohibited this industry, Wisconsin factory cheese is now regaining its former standing. These two States have such a preponderating influence that they give character to the entire cheese output of the country.

MANUFACTURE AND COMPOSITION OF CHEESE.

In America cheese is made of different sizes and shapes, and is of numerous kinds. A number of the varieties commonly associated by name with foreign countries are imitated with more or less success. The great bulk of the American output, however, is of the familiar round form, 14 to 16 inches in diameter and from 4 to 12 inches thick, ranging in weight from 30 to 80 pounds, with an average of about 60 pounds, and of the same texture and appearance throughout. This form takes the name of Cheddar, from a parish of that name in Somerset County, England, long famous for producing cheese of the same general character and style, and made in substantially the same way.

Cheese may be made from sweet or sour milk. The milk may be in its natural condition or skimmed fully or in part, or it may be enriched by the addition of cream in excess of that belonging to it. The different varieties of cheese depend upon the character and condition of the milk used, upon seasoning, upon peculiarities in the different processes of manufacture, and especially upon the conditions and treatment incident to the curing or ripening.

The first step in cheese making is to bring the milk into the form of curd. This may be done by allowing it to sour in a natural way. But in most cases cheese is made from sweet milk and curdled with rennet, a ferment obtained principally from the stomachs of calves. If the curdling or coagulation takes place before cream has separated, nearly all the fat of the milk and some of the milk sugar is held in the curd. About two-thirds of the water of the milk, the greater part of its sugar, a considerable part of the ash, and the small quantity of albumen present form whey, which is the only refuse produced in cheese making. Some milk fat may also escape in the whey, but this depends upon the skill of the maker.

The component parts of cheese, as well as of milk, are water, casein, fat, sugar, and ash or mineral matter. These parts differ much in proportion in the various kinds of cheese. Numerous analyses made, principally by English chemists, give the average composition of several well-known varieties of cheese as stated in the table following. The composition of milk is included for the purpose of comparison.

It is thus seen that cheese contains practically all of the casein of the milk from which it is made; and it is shown that good cheese may be roughly stated to be one-third water, one-third fat, and one-third casein, sugar, and ash (together). It is therefore a strong nitrogenous or flesh-forming food, and as a food too concentrated to be eaten by itself in quantity.

Composition of varieties of cheese.

Variety.	Water.	Casein.	Fat.	Milk sugar.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Milk	87.00	3.40	4.00	4.90	0.70
American full cream—Cheddar	38.00	25.35	30.25	1.43	4.97
English Cheddar	35.41	27.61	31.03	2.00	3.95
Stilton	30.35	28.85	35.39	1.59	3.82
Edam	36.28	24.06	30.26	4.50	4.90
Neufchâtel	44.47	14.60	33.70	4.24	2.99
Roquefort	31.20	27.63	33.16	2.00	6.01
Gruyère	34.87	25.87	29.91	5.51	3.84
Parmesan	31.34	41.99	19.22	1.20	6.25

As an article to be included and liberally used in a regular diet, cheese has been found to be very wholesome and very economical. It is worthy of note that statistics of the diet of public institutions show that in those which are in charge of physicians, like asylums and hospitals, the consumption of cheese per capita is large. In many cases the rate is twice as much as in other institutions and with people in general. This is an emphatic and practical testimonial to the value of cheese as food on the part of numerous members of the medical profession.

INCREASING THE CONSUMPTION OF CHEESE.

The value of cheese as an article of food has long been recognized, and it deserves a much more prominent place among household supplies in this country than it has ever received. It has been said that "Americans taste cheese, while Europeans eat it." In Great Britain and most of the countries of Europe cheese is one of the chief articles of diet, replacing butchers' meats to a considerable extent with large classes of the people. This substitution is found to be very economical and satisfactory to the consumers. In these foreign countries the consumption of cheese per capita is several times as large as in the United States.

This low rate of cheese consumption in this country can be explained in part, undoubtedly, by the general supply of meats at comparatively low prices, and the fact that it has not been regarded as necessary to select foods so that every dollar expended would purchase the greatest possible amount of nutritive material. Information concerning the relative value of various articles of food has not been general. The subject of human nutrition has received much attention within the last few years, however; facts are rapidly accumulating and are being widely diffused. This movement is very certain to lead to a better recognition of the food value of cheese and its comparative cheapness, and to a consequent increase in its use.

It seems clear that a taste for cheese has never been generally acquired in this country. In those families where it is liked, it is

ordinarily used in small quantity as a side dish or relish, and at usual retail prices it is regarded as expensive. Further, when a pound or two is cut from a cheese of the common form and size, a very large cut surface is exposed to the air, and, as it is seldom that special attention is given to keeping it fresh and moist, the piece of cheese soon dries out, loses flavor, hardens, and becomes unpalatable. Again, if one forms a fondness for a particular consistency, stage of ripeness, and flavor in cheese, it is often found difficult to get just the article desired when more is wanted. There are other minor reasons connected with the retail trade in cheese, as commonly conducted, and with the way in which the article is treated in the household, which tend to dissatisfaction on the part of the seller and buyer, and prevent increase in the traffic and in consumption.

It is useless to argue that when compared with meat and many other articles as to actual food value, cheese is rarely retailed at excessive rates. It still remains a fact that the retail price of cheese is usually considerably more than is justified by the wholesale price when compared with articles which can be similarly transported and have similar keeping qualities. There seems to be no good reason why cheese which sells at wholesale at 8 to 10 cents per pound should be retailed at 15 to 17 cents, and often at 20. The usual margin between the wholesale and retail price of cheese is far too great, and yet the net profits of the retail dealer are not unreasonable. When kept by the general grocer, he will insist that there is very little profit in cheese, and proves his claim by showing no inclination to specially increase his sales of the article. When a large cheese is cut, sales must be active to prevent drying and other deterioration which results in loss. Altogether, prevailing conditions do not favor an increasing retail trade in cheese of regulation form, conducted in the ordinary way.

Manufacturers and merchants should unite in efforts to "tickle the palate" of the consumer, and increase the sale and use of cheese. A very few pounds more consumed by every family every year would give a wonderful impetus to the business, and be a boon to dairy interests in general. There are advantages in the manufacture and transportation of large-sized cheeses, and they are well suited to the export trade as it now exists, or to what there is left of it; but a cheese of 40 pounds and over is not well adapted to the greater part of the retail trade. The ideal cheese for retailer and consumer is one ranging from 4 to 12 or possibly 15 pounds in weight, which is suitable for family use, to be sold uncut. Difficulties have been encountered in making small cheeses of the standard type which would keep well. When the exterior surface bears too large a proportion to the bulk, they dry out easily. These objections have been gradually overcome, however, and as good a cheese, of as good keeping quality, can now be made of 15 pounds' weight as of 60 pounds. Small sizes encourage customers to buy, if the quality is maintained, and they

can be used up in the family while still good. Retailers delight in a cheese that can be sold "in the original package," and can well afford to reduce the price in such cases. But now, as for years past, these small cheeses of domestic manufacture are so scarce in the markets as to command a premium, and actually sell for more than those of standard size, although the loss to the retailer from handling is less. This is not because of higher quality, but because they are "so handy." The "Young America," of 7 to 12 pounds, should be multiplied till all can have them. Cheese of the standard American factory, or Cheddar, character, but smaller in size, should be more generally introduced. Even if made so large as to necessitate cutting, the size can well be reduced to from 15 to 25 pounds to the great advantage of a large part of the retail trade. This is shown by the popularity of the "Ponys," "Picnics," "Little Favorites," and others of this character. Such cheeses can be disposed of whole, or sold off quickly after being cut, avoiding the common loss. Several instances might be mentioned of factories which have for years made a specialty of cheese of the standard kind, but of small sizes, and which have secured special prices by the operation. It seems strange that these examples are not followed until in all our American markets small cheeses, in sizes to suit the wants of purchasers, are as common as assorted sizes of shoes. This being done, merchants will be found ready to retail cheese at an advance of 15 or 20 per cent upon the wholesale price. There can be little doubt that good, full-cream factory cheese, retailing at 12 or 13 cents, in packages of convenient size, would result in a very material increase in the aggregate consumption of this article.

Superior quality is, of course, an absolute necessity. Our people, as a rule, are more particular about the quality of what they buy for their tables than about the price. For activity in trade and increased use of cheese in this country, the makers must be skilled and careful, and must produce straight, honest goods, of whole milk of good quality, giving a cheese uniform in character and up to the standard which has been found attainable in our best cheese-making sections for many years. The Southern States have always been large buyers of cheese. There have lately come from that section numerous complaints of losses sustained by merchants and consumers by having large lots of adulterated or "filled" cheese palmed off upon unsuspecting buyers. These goods are put up attractively, in various sizes, are bright in appearance, and the quality when fresh is such that it is very difficult to detect them. Being offered at a few cents below the ruling market price for standard goods, they present to retailers the temptation of large profits. But they soon deteriorate, and dealers and consumers, who have paid from 12 to 16 cents, or more, for the stuff, become disgusted and, being unable to protect themselves against like imposition again, decide not to risk further loss of money

on such food, and discontinue the purchase of cheese. A marked decrease in consumption has resulted, and merchants at the principal distributing points note a decided falling off in orders from the South.

This adulterated cheese, in which the natural fat of milk is replaced by some cheaper fat, usually lard, is often fraudulently branded "New York State Full Cream," "Herkimer County Fancy," or "Extra Wisconsin Factory." The deception is sometimes but slightly veiled by a "Beaver State" brand, to take the place of "Badger State," the stencil trade-mark representing something which may be a hybrid of these two animals. Vigorous measures are necessary to put a stop to the disastrous effects of these frauds upon home consumption and domestic trade.

For the present, the only safe plan is for merchants to buy only such cheese as is plainly branded in accordance with State laws. Every full-cream cheese from New York and Wisconsin is, or should be, branded as such with an official stencil on the cheese itself, including the number of the factory, which is registered, so that every cheese can be traced to the place where made. In both those States the manufacture and sale of adulterated or "imitation" cheese is prohibited. In Ohio, Minnesota, and Colorado there are similar laws for branding. If consumers would insist upon seeing the marks upon the cheese they buy, and the boxes they come in, and buy only of reputable merchants, and if the latter would take the same precautions, good cheese could be secured with great certainty. If a case of substitution of counterfeit goods occurred, it could, upon detection, be traced back to the party responsible for the fraud, and damages could probably be recovered.

Variety is another very important consideration. By variation in the general cheese-making process, milk can be converted into forms differing greatly in appearance, general character and flavor—and smell also. Cheese can be made to suit all tastes, at least all cheese tastes. Merchants and manufacturers in this country do not avail themselves as they should of the opportunities in this direction. It is true that a considerable number of different varieties of cheese are imported from foreign countries, but in very inconsiderable quantity. Several of the favorite imported varieties are now imitated in this country, with varying success, but not in large quantity. The great mass of American cheese is of a single type. If it be assumed that all of the 9,000,000 pounds of cheese which constitute our average annual importation is in the form of foreign varieties, and that half as much more, of similar kinds, is made in the United States, this would constitute but 5 per cent of the yearly cheese supply of the country. Yet variety in forms and kinds of cheese is happily on the increase in America. For more than fifty years the small, somewhat dry and hard-rinded cheese in the favorite pineapple form has been successfully made in Connecticut and other places, as well as imported from

England. Another variation from the ordinary style, even older than this, is made by an admixture of the leaves of sage.

The bright red, spherical Edam, from Holland, is a dry and hard-shelled kind, which is very popular on account of its flavor, and also because of its convenient family size. This variety is made well in Wisconsin. The big cart-wheel Gruyère, with its sallow complexion and peculiar gas holes, is also imitated in Wisconsin, but not so successfully. The genuine must be a general favorite, for fully half of all our cheese imports are from Switzerland, nearly all being this "schweitzer-käse." This kind of cheese is also to be found in the more convenient form of large bars, weighing about 20 pounds each. Two varieties which may be called especially aristocratic are the rich English Stilton and the French Roquefort, with its characteristic blue mold. These are quite expensive and all imported, although efforts have been lately made to produce "American Stiltons." Some years ago a factory in Maine, which handled only milk from Jersey cows, turned out a cheese at certain seasons which good judges pronounced to be equal to a genuine Stilton. The Parmesan is brought from Italy in large quantities, forming nearly one-fourth of our cheese imports. Our people are not likely to imitate that variety very soon if it should require here, as in its native land, at least three years in the curing. Limburger comes from the Netherlands, standing next to the Parmesan in quantity imported. A very good article under this name is made in numerous places in this country, and a form of lard-cheese substitute is also largely sold in the West. Sapsago, or, more correctly, Schabzieger, is imported to a limited extent. The rich, soft, highly odorous cheeses, in flat, round, and brick forms, from France and Italy, like the Brie and D'Isigny, are well made in New York and Pennsylvania, and also imported. The delicate little Camemberts, soft, white, with blue penciling, and sometimes reddish on the outside, are nearly all imported. The much plainer form of curd, fresh made and sold cheaply in nearly all our markets, in little cylinders wrapped in tin foil, under the name of Neufchâtel, has been made in large and steadily increasing quantities for fifteen years or more in New York and Pennsylvania. The same localities place in market a soft, fresh curd, much enriched, which is called cream cheese.

This by no means exhausts the list of varieties which can now be found in all good markets in this country, although most of the favorites have been named. The standard American Factory, or Cheddar, cheese also appears in several more or less disguised and fancy forms, some quite attractive. The Canadian and American "Clubhouse" cheese, "Meadow Sweet," "Saratoga," and "Delicatesse," sold in 1 and 2 pound jars and in smaller packages neatly prepared, are simply good selections of common factory make, taken at a stage of ripeness, mild or strong, to suit the taste, then worked over, pressed into suitable packages, and sufficiently enriched to make a uniform

smoothness. Flavor is increased in some instances by adding a little wine or brandy. "Cheese Food" is also standard cheese into which has been incorporated the natural whey reduced to a sirup; this gives a sweet taste to the cheese, which some like, and restores the original equilibrium of the milk components. All of these rich and fancy forms of cheese must be recognized as relishes, to be used in small quantity, rather than as a substitute for other food.

Variety in form and flavor should be encouraged as likely to please a greater variety of tastes and increase its consumption. Dealers and consumers should cooperate in extending the trade in "fancy" cheese. Dealers can create a demand by increased variety and display.

If buyers would take a little trouble to properly care for the cheese they purchase, it would keep better, there would be little loss, and housekeepers would be encouraged to use more. Retail merchants would do well to distribute simple directions to this end. Nearly all kinds of cheese while awaiting use in the household should be kept in a special vessel from which the air is excluded. A stone jar with a tight-fitting cover is a suitable receptacle. This should be placed in a storeroom or dry cellar where the temperature is constant at 50° to 60° F. The air must not be so free from moisture as to dry out and harden the cheese, nor so damp as to promote the growth of mold. Trial will easily determine a suitable place to keep the jar, which should be thoroughly scalded and well aired after being emptied of one lot of cheese before another is put in. This should never be forgotten. There are some molds, or germs of ferment and decomposition, susceptible of growth in such a vessel if too long neglected, which might prove dangerous. In case a large cheese is bought for family use, instead of cutting off a little at a time, constantly leaving considerable surfaces to dry, enough should be removed to last two or three days, and the entire surface of the remainder should be rubbed with some heavy oil. A mixture of beeswax and salad oil, worked to the consistency of soft butter, has been recommended for this purpose. Epicures advise cutting cheeses like the Stilton and Young America across one end of the cylinder and keeping them with the cut surface downward in a soup plate filled with old ale. An Edam may be similarly cut and preserved. Cheeses of the shapes last mentioned may be cut directly in two, and then used from the cut surfaces, leaving these smooth, so they will fit closely together; the air may thus be largely excluded and rapid drying prevented. If cheese in large pieces or fragments becomes dry and hard, it should not be rejected, but used for cooking purposes, either grated or melted. For such purposes none is better than the common American factory cheese.

EXPORT TRADE IN CHEESE.

Important as are the home markets and increase in domestic consumption to the cheese interests of the United States, the foreign markets, and especially the British market, are even more so. Within

twenty years, more than half the season's cheese product of this country has been taken to meet foreign demands. Recently this export trade has fallen off to less than one-fourth of the total output. This is a very serious matter, requiring examination and explanation.

From the beginning of the century, exports of cheese from this country increased, year after year, with no fluctuation of consequence, until the maximum of 148,000,000 pounds was reached in 1881. Great Britain took nearly all of these exports, and, as the trade grew, branches of large Liverpool houses dealing in cheese were established in New York. At one time there were forty foreign cheese buyers located in that city. During this period of increasing trade the quality of the goods steadily improved, until cheese from "the States" stood at the head in English markets for imported products. From 1870 until 1882 the export price of our cheese at New York averaged about 12 cents per pound. Canada was also a very good customer for the cheese made by her southern neighbors. Comparatively little cheese was made in Canada, and under the freedom from commercial restrictions which prevailed for ten years prior to 1865 the United States found a good market for 500,000 to 2,000,000 pounds of cheese per year north of the St. Lawrence and the Lakes.

The past fifteen years have brought great changes in these conditions and relations, all detrimental to the cheese interests of the United States. The Canada market (for consumption) has been entirely lost, and exports to Great Britain have decreased to little more than one-third of the high-water mark. English buyers residing in New York have almost disappeared. Accompanying this loss of trade has been a disproportionate reduction in prices, owing to a lowering of quality and consequent loss of reputation. Meanwhile, Canada appears to have gained what the United States has lost. Her cheese exports, which amounted to nothing prior to 1865, have grown continuously, until they greatly exceed those of this country, and Canadian cheese now sells in the London market at a higher price than that from the United States. One effect of this condition has been to cause more than 10,000,000 pounds of cheese per year to be shipped across the border, particularly from Wisconsin and New York, to be reexported from Canada under cover of the superior reputation of Canadian cheese. This is humiliating. In a brief discussion of this subject in the current Annual Report of the Secretary of Agriculture of the United States (p. 29 of this volume) this statement is made:

During the first eight months of last year (1894), Canada and the United States stood side by side in supplying the English market with cheese; but, whereas Canada has this year not only held her own but made a slight gain, shipments from the United States have fallen off 117,000 hundredweight, an amount about corresponding to the increased shipments of Australasia and Canada, and to the falling off in the total imports into Great Britain. In fact, every country shipping cheese to Great Britain has this year enlarged its trade with that country except the United States, which has lost over 21 per cent of its last year's business.

The statistics which show this deplorable condition of affairs are given in the table below, and the same facts are presented in graphic form by the diagram which follows. Temporary variations in markets make it often misleading to compare the figures for single years, and therefore averages are also used for several consecutive five-year periods.

Exports of cheese from the United States and Canada for single years and yearly averages for five-year periods.

Periods.	United States.	Canada.	Periods.	United States.	Canada.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
1850	10,361,189	17,100	1881-1885	118,813,685	61,502,949
1860	15,515,799	124,320	1886-1890	88,303,513	83,737,133
1861-1865	35,081,855	473,550	1891-1895	75,977,115	131,679,207
1866-1870	47,423,602	3,750,224	1893	81,350,923	133,946,365
1871-1875	90,688,546	20,114,561	1894	73,852,134	154,977,480
1876-1880	113,606,609	40,676,856	1895	60,448,421	146,004,650

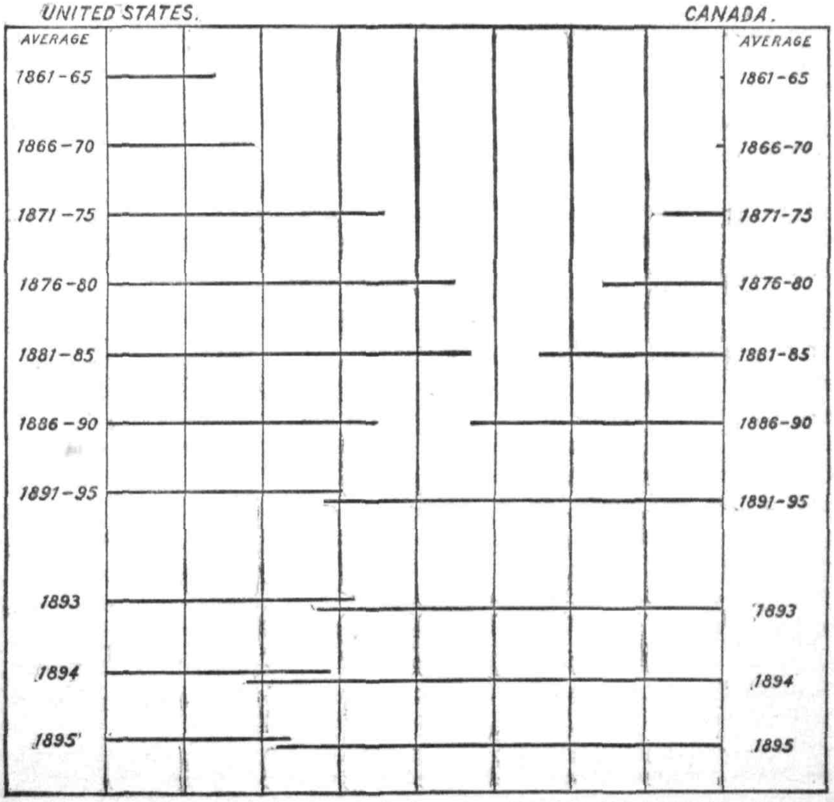

FIG. 121.—Diagram showing exports of cheese from the United States and Canada.

The figures in the table do not include the cheese received in Canada from the United States and reexported. The growth of the Canada cheese trade, almost exclusively with Great Britain, is enormous. Since 1860, the increase in quantity is a thousandfold. Then Canada exported less than one-hundredth part of the quantity sent from the United States. Now the cheese export of the former is more than double that of the latter in quantity and nearly 10 per cent greater in value per pound.

Another quotation from the report of the Secretary of Agriculture is applicable here:

> No one can peruse the above facts and figures without arriving at the conclusion that unless our shippers of cheese pursue a very different course, the history of our foreign trade in that product will speedily fall, in the face of active, intelligent, and honest competition from all parts of the world, to the level now occupied by American butter. We have here a graphic illustration of the disastrous effects in all trade of disregarding the tastes of consumers and of acquiring a bad reputation.

Chief among the causes of the unfortunate condition of the foreign cheese trade of the United States are these: (1) Restrictions placed upon the freedom of trade between the United States and Canada; (2) the energy and success of the Canadian Government in developing and improving the production of cheese in the Dominion; (3) the short-sighted policy of cheese makers in the United States in turning out so many poor goods and ignoring the tastes and demands of foreign customers; (4) the exportation of so much low-grade cheese, or "skims," and of adulterated goods or "filled cheese" in defiance of the requirements of British markets and the consequent degradation of a well-earned reputation. These leading causes of existing conditions may be briefly reviewed.

STATISTICS OF DAIRY INTERESTS OF CANADA.

During the first six decades of the present century the dairy interests of Canada were undeveloped, production amounted to little, and exports were insignificant, only reaching 100,000 pounds of cheese in 1860. Under the operation of the reciprocity treaty of 1854, the United States supplied Canada for ten or twelve years with a large part of the cheese consumed, amounting to some millions of pounds a year, as already stated. Canada was one of our good markets for cheese. The interruption of those advantageous trade relations closed those markets to us and gave a great incentive to dairying in Canada. This was the beginning of the rivalry in foreign trade on the part of Canada which is now causing the cheese interests of this country so much trouble. In a report of the Montreal Board of Trade, dated April 9, 1868, occurs this passage:

> The repeal of the treaty has stimulated the erection of cheese factories, which are shutting out the products of foreign dairies from the Canadian market and enabling the dairymen of Canada to compete successfully with their American neighbors in sending supplies to the British market.

In 1865 there were less than a dozen cheese factories in all Canada. During the year 1866, 60 factories were opened, and the number trebled in two years. In 1871 the number reported was 353, in 1881 it was 709, and in 1891, the latest report, 1,565 factories were in operation. For fifteen or twenty years the Canadian Government has made strenuous efforts to develop the dairy interests; grants have been made to associations of dairymen, institutes and local schools have been supported, and an executive department of the Dominion established, with branches in the different Provinces, under which dairy literature is widely distributed and skilled instructors sent from factory to factory teaching the most approved methods of making cheese. One result is seen in the great increase in cheese production—23,000,000 pounds in 1871, 61,000,000 in 1881, 109,000,000 in 1891, and now, by estimate, 160,000,000 pounds a year—and quality accompanies quantity. Canada prohibits by law the manufacture of skim cheese and of filled cheese, and there are no indications of effort on the part of makers or merchants to evade or violate these laws. Government and people have united in the improvement of processes and products, and in studying the tastes of their customers and satisfying them. The result has been to establish a reputation which places Canadian cheese at the head of the foreign markets. The very best cheese from the United States now sells more readily in London if bearing a Canadian brand than under the names which, but a few years ago, were accepted as a guarantee of all that was honest and best in cheese. From this plain statement of facts, dairymen, cheese makers, tradesmen, and exporters in the United States may find useful material for burnishing a sadly tarnished reputation, a matter which needs immediate attention.

THE MANUFACTURE OF SKIM CHEESE IN AMERICA.

It is impossible to determine exactly how and when some American factories, organized and established with the sole idea of making whole-milk cheese, began to manufacture skim cheese, and to add butter making to their other work. It seems, however, to have resulted gradually, from a combination of natural and economic causes, beginning very soon after the factories became numerous. Thus, late in the season, when milk diminished in quantity, grew richer, and kept longer, patrons at a distance from a factory would deliver only every other day, and the cream having separated on the earlier messes, they would remove it, to make butter for home use, and so send to the factory milk with but a half or a third of its cream; yet the factory cheese made from this milk would be apparently equal in quality to the average of the season. Again, factories receiving a part of their milk in the evening, and failing to prevent a separation at night, would try removing and churning the cream of that part, and still make good cheese. There were good cheese makers who noticed a

large percentage of butter in the whey, and they claimed that this might be saved by taking more or less cream from the milk for butter, before making into cheese, and without detriment to the latter product. Frugal factory managers, too, discovered that they could turn out as many or more pounds of both butter and cheese, from a given quantity of milk, as of cheese alone, and could sell the double product for more than the single one. Facts like these, and the results of such experiments, were soon heard in meetings of dairymen, and became arguments for more or less skimming.

Prof. X. A. Willard, of Little Falls, N. Y., the most active and prominent exponent of American cheese-factory practice in the early years of the system, favored skimming within bounds.

Prof. L. B. Arnold, of Rochester, was the closest student of the dairy and of improvements in cheese making of his time. He did not believe that the usual loss of butter fat in the whey was necessary. He regarded no natural milk too rich for good cheese, and he did not directly advocate skimming.

In an article on American dairying, the present writer said, when referring to this subject, in 1880:

> With such teachers and teaching, and with the balance sheets of factories adopting this advice showing better returns than those adhering to their whole-milk principles, it is not surprising that skimming became common; factories produced more or less butter, and changed their plans accordingly. From the outset, however, there were stout opponents to all skimming in connection with cheese manufacture, conspicuous among them being makers whose "marks" had won a high reputation, and merchants who prided themselves on keeping a high standard in the markets.

The American Dairymen's Association, after long consideration and full discussion of the subject, adopted ringing resolutions declaring against all skimming and in favor of maintaining the full-cream standard for American cheese.

But selfish motives have caused skimming to continue, and there has been little serious effort to stop the practice. For years the markets have been accustomed to skim cheese, to half skims, and to cheese resulting from skimming in all degrees. The State of Ohio has recognized the practice in law and attempted to grade the products. This cheese has found its place in the home trade and has entered into our exports. There is just about the same proportion of skims and part skims in the market the present year that there has been in years past.

Two very unfortunate features are associated with American skim cheese: First, unlike the ripe and finely flavored Parmesan, our skims are mostly flat in flavor, hard and horny, so much so as to be familiarly known as "white oak" cheese; second, the better class of part skims have been unscrupulously sold while at their best for the genuine full-cream article. The general reputation of American cheese at home and abroad has necessarily suffered in consequence.

It can not be denied that skim cheese is a legitimate food product, and if well made it is highly nutritious. There may always be room for more or less of it in the market, but it should always be plainly marked, sold for exactly what it is, and at prices suited to its kind.

OLEOMARGARINE CHEESE.

"Filled cheese," which is regarded as having so injuriously affected the cheese interests of this country within very recent years, and especially our foreign trade, is by no means a new article, although this is a comparatively new name. Very soon after oleomargarine began to disturb the makers, merchants, and consumers of butter in America, oleo oil came into use in the manufacture of cheese. Combining this oil with skimmed milk, as an emulsion, it was found that an article could be made having, when fresh, the appearance of a good, rich cheese. Patents were issued upon the process and mixing machinery about the year 1871, and the making of "oleomargarine cheese" was begun at Ridge Mills, near Rome, N. Y. One of the oldest and most reputable dairy-apparatus establishments in the country secured control of the special machinery required, advertised it extensively, and a good many factories were fitted up to produce the new cheese. The same firm still controls the patents.

In writing upon the subject in 1881, Prof. J. P. Sheldon, one of the first dairy authorities of England, expressed these views:

> There has been much discussion and controversy on the other side of the Atlantic as to the merits of oleomargarine cheese. It has its friends and its enemies. It has been vigorously attacked and vigorously defended, and now awaits the decision of that final court of appeals in such cases, public opinion. Controversy seems to be useless. This kind of cheese appears to be a perfectly wholesome article of food, and, so long as it is honestly made and as honestly sold, it is a legitimate addition to our food supply that may justly claim to stand or fall on its merits; but if it comes to be palmed off on the public as pure-milk (full-cream) cheese, it at once forfeits its claim to be treated with fair play.

The forfeiture thus suggested has certainly been made. As already stated, this oleo cheese, lard cheese, or filled cheese, comes into market under every name except its own. Its true character and proper designation are recognized only while in the hands of the manufacturers' agents, and when it moves from the principal distributing point the various brands upon it give ample evidence of the intent to deceive and defraud. The appeal to public opinion has been made, and the response is emphatic. Reputable merchants and exporters generally refuse to handle the article. New York and Wisconsin absolutely prohibit its manufacture and sale. Other States have followed and are following in the same course, or at least establishing restrictions and providing for identifying marks. The only legislative contests in which filled cheese triumphed were in Indiana and Illinois. Chicago has become the chief depot and distributing point for this commodity. Even "filled" Limburger and "brick" cheese of American manufacture can now be found in that market.

The materials from which this cheese is made are very cheap. Its base is skim milk, which is so abundant in the creamery districts as to be a waste product, with hardly any value, being, unfortunately, neglected by farmers, who fail to appreciate its real worth. The fats added may be oleo oil, or neutral lard, or butter of lowest grade which has been put through questionable processes for renovation. Still cheaper fats may be used. It is claimed that the cheese can be placed in market at a cost of 4 or 5 cents per pound. In large lots it is freely offered at three-fourths the price of first-class cheese, or less, and yields a large profit at this rate. Like the butter substitutes and imitations, the manufacture of filled cheese has greatly improved. A good grade of neutral lard is generally used, and the product now comes into market appearing so fine in quality and with so clean a taste as to be very deceptive and hard to detect by ordinary sampling. But there is an absence of flavor or aroma, and its quality is short lived.

Although not made in very large quantity (probably 500 to 600 tons per month), there is yet enough of this adulterated cheese, and enough unscrupulous dealers to push it in all directions for the sake of the unusual profits, to badly demoralize trade in honest goods and greatly impair the reputation of American factory-made cheese, both at home and abroad. The evil effects upon domestic trade have been noted. The recent rapid decrease in exports is largely attributable to loss of confidence resulting from its sale abroad under false colors. The fraudulent article, as now made and handled, is a serious menace to all honest cheese, and the vigorous warfare against it in England and Canada and the rising tide of popular disapproval in the United States are fully justified.

WAYS TO IMPROVE THE TRADE IN CHEESE.

The suggestions made in previous pages, with a view to increasing home consumption, are of minor importance when compared with the need of general improvement in domestic trade and the export of American cheese. Such improvement seems to depend mainly upon two conditions: First, quality; a higher standard must be set for our cheese and strenuous efforts made to induce all makers to attain to it, thus raising the average quality and securing reputation. Second, prevention of fraud; effective measures are necessary to restore confidence, so that all buyers may get with certainty what they want and pay for.

All interests centering in cheese production demand superiority of quality and economy in production. Factory managers and cheese makers need to have the lesson impressed upon them that in honest markets the best goods are the easiest sold and the most profitable. They must be constantly on the watch for improvements and economies in manufacture. The wants of special markets and the fancies of buyers must be studied and satisfied. The British market, still

our largest customer, continues to want a large cheese, rich, well cured, and firm in texture. The demand of the home market is not so fixed but the general preference is for a smaller cheese, comparatively new, mild and rich, of medium texture and color. Following the example of Canada, the leading cheese-making States may well employ expert itinerant instructors to work at farmers' institutes, at dairy conferences, and in the factories themselves. This has already been done in New York, with satisfactory results. The dairy schools established in several States are doing excellent work, and the influence of their graduates is showing itself in the dairy community at large. To these schools especially is due the credit of demonstrating the fallacy of the old idea, responsible for so much unfortunate skimming, that considerable butter fat was necessarily lost in the process of making cheese. Instead, the principle has been established that no milk is too good for good cheese, none too rich for rich cheese.

This principle was admirably shown by an exhibit from the dairy school of the University of Wisconsin at the Columbian Exposition. Six cheeses were placed side by side which had an interesting origin, and constituted a valuable object lesson. The dairy pupils at Madison, as an application of the principles they had been taught, divided a large quantity of milk of uniform quality into six parts. Then, by different degrees of cream separation, the percentage of fat in the milk of each lot was fixed exactly as desired. Almost all the fat was taken from lot 0 (see fig. 122), and a good deal was added to lot 5. Just 300 pounds of milk was weighed from each lot, the six having these percentages of fat, respectively, 0.2, 1.3, 2, 3, 4, and 4.9 per cent. The numbers given to designate these lots of milk and the cheeses resulting, 0 to 5, thus indicate the nearest percentage of fat in the milk expressed by a whole number; reasons for numbering thus will presently appear. These lots of milk were made into six cheeses, without appreciable loss except pure whey. All were pressed in 10-inch hoops, so the only difference in size was in the thickness. The cheeses were weighed green on April 17, 1893, when taken from the press, and the cured weights were recorded June 26, when they were sent to Chicago. Weights and other figures are given in the following table:

Influence of fat upon yield of cheese.

Number or lot.	Pounds of milk used.	Per cent of fat in the milk.	Weight of cheese, in pounds.	
			Green.	Cured.
0	300	0.2	18.4	13.0
1	300	1.3	22.4	19.0
2	300	2.0	24.0	21.5
3	300	3.0	27.0	25.0
4	300	4.0	29.0	27.0
5	300	4.9	31.9	30.0

These figures are very suggestive. The richer the milk, the greater the quantity of cheese, green or cured, from a fixed weight of milk. Without regard to quality, the best milk made more than twice as much cured cheese as the skim milk, and the richest cheese lost the least in curing—very much less than those partly skimmed.

As exhibited these cheeses looked like this:

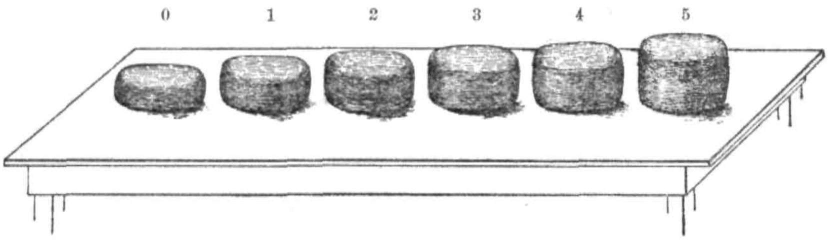

FIG. 122.—Diagram showing influence of fat upon yield of cheese.

The contrast was marked and the lesson conclusive. The richer cheeses had more bulk to the pound than the poorer ones; hence No. 3 was fully twice as thick as No. 0, and No. 5 still thicker in proportion to weight. Before being cut and tested, it was plain that the one containing the most milk fat was much the best cheese. The market sequel or financial result in this case is noteworthy. Exact duplicates of these cheeses, upon being sold, gave these results, in part: No. 0 sold for 5 cents a pound, or 65 cents, being really more than usual market rate for such thoroughly skimmed cheese. No. 3, at 9 cents, brought $2.25; No. 4, at 10 cents, $2.70; and No. 5 sold easily at 12 cents, because of its extra quality, bringing $3.60. All these were wholesale prices. Now, if the fat in Nos. 3, 4, and 5, in excess of that in No. 0, had been made into creamery butter, without loss, the respective quantities would have been 3½, 4½, and 5½ pounds (very nearly), which, at 25 cents per pound, would have brought $0.88, $1.13, and $1.38. Add to these amounts for butter, the worth of the skim cheese, No. 0, and the gross receipts from the lots of milk, 3, 4, and 5, made into skim cheese and butter, would have been $1.53, $1.78, and $2.03, as against $2.25, $2.70, and $3.60 from the same lots of milk, unskimmed, made into good cheese. The profit is largely in favor of the cheese in every case, and the richer the milk the larger this profit. Manifestly "it did not pay" to skim in any of these cases, and it rarely does pay, even if good cheese is made. No more conclusive argument could be presented than by the facts and figures in this case to prove that no natural milk is too rich to make cheese with success and profit.

A series of instructive cheese experiments at the Iowa Agricultural Experiment Station bears upon this same question. Cheese was made there from milk ranging in fat content from 1.75 per cent, by 15 gradations, up to 8.4 per cent. It was found that the richer the

milk the fewer pounds it required to make a pound of cheese, and the per cent of loss in the making of the original fat in the milk, always small, was no more with milk of the extreme richness stated than with standard milk and skimmed milk. Similar results have been obtained in Vermont, New York, and Minnesota.

Cumulative evidence is unnecessary. These important truths are established, namely: The best milk makes the best cheese, and the most of it; the milk which is most profitable for butter is also the most profitable for cheese; the best butter cow is the best cheese cow.

Other things being equal, a cheese containing a large percentage of fat is better, because, first, of finer flavor and taste; second, of its better consistency; third, of its improved aroma; fourth, of its increased digestibility; fifth, of its more perfectly answering the requirements of a complete food or "balanced ration."

NECESSITY OF CLASSIFYING AND BRANDING CHEESE.

Something should be done to abate the evils resulting from promiscuous skimming. As now made and sold, the partly skimmed cheese is generally deceptive and bound to make trouble, more so than the full skims. The legitimate demand for these low grades of cheese is limited, and the main reason for their manufacture is the utilization of skim milk. There are vast quantities of skim milk, fully skimmed, which are too valuable to waste. This should all be used as food by man or beast. If some of it must be preserved and made into cheese, the nature of the product should be in some way clearly indicated upon the article itself. "Full skims" generally show plainly enough what they are, but as to "part skims," the degree of skimming varies so much that it is hard to draw the line between these and some cheese made from whole milk. Pure milk differs so much in fat that unless a definite standard be fixed for "full-cream" cheese, lots entitled to this designation may actually differ as much in fat content as some full creams do from "half skims." A graded system of classification and branding should be adopted which will show, approximately, the composition, and hence the grade, by the marking. The simplest and most effective regulation for skim cheese is the Wisconsin law:

Any skimmed-milk cheese, or cheese manufactured from milk from which any of the fat originally contained therein has been removed, except such cheese is 10 inches in diameter and 9 inches in height, is prohibited in the State, for manufacture, purchase, sale, or transportation. (Sec. 2, chap. 30, Laws of 1895.)

This is a drastic measure, but in many respects is much better than any branding.

In regard to filled cheese, it is evident that some regulation will be demanded and obtained to at least prevent the perpetration of fraud wherever large cheese interests prevail. So long as any States permit unrestricted manufacture and sale, the evil will continue to threaten

the Southern trade, as already noted, and, indeed, the entire cheese trade. Hence the demand for national legislation.

The tendency to seek legislative relief upon all occasions of embarrassment is very unfortunate. A self-respecting people should exhaust all other means to help themselves. Calling upon the law-making powers should be the last resort. If it is found that nothing short of legislation by Congress will meet the case, then the mildest enactment that will effect the object is all that should be asked for. Prohibitory laws are repugnant to a large part of our people. They do not accord with accepted principles of individual and commercial freedom. There is no excuse for destroying the business of one set of men in order to improve that of another set. The claim that cheese producers must have their interests protected at all hazards is neither sound nor politic. "Live and let live" should be the motto for dairymen and all producers. The people who need most to have their rights and interests guarded are the merchants and the consumers. All they need is to be protected from imposition and fraud. Such regulation as will enforce honesty in trade and secure to everything its right name will answer the purpose.

All forms of cheese, full cream, skimmed, and filled, should be so made or marked as to insure their identity all the way from place of manufacture to the consumer of the smallest fraction. Methods of accomplishing this can not be determined without the fullest consideration of the subject. But certain points are plain. The branding and marking of packages and wrappings is not enough. Distinguishing marks should be placed upon the cheese itself. And far better than a simple stencil and easily obliterated bandage mark would be a sunken brand pressed into the top and bottom of every cheese, so that some of it would remain visible and serve for identification to the last pound of a cut cheese. This practical and effective method of marking is of Danish origin, having been successfully used there for years. The registry number of factory and brand, as now used in New York and other States, should be retained, so that every cheese can be identified and traced to the place of manufacture. "Lard cheese" is probably the best designation for the "filled" article, being short, distinct, and accurately descriptive. It will be hard to substitute anything for "full cream," as the brand for the genuine product, although "pure milk" would be more correct, and better for several reasons.

It would be manifestly unfair, however, as already shown, to brand all cheese alike and give it equal legal standing, as well as commercial, simply because made of pure, whole milk, regardless of the quality of the latter. In well-made cheese the fat content is manifestly the measure of quality, and this is determined by the percentage of fat in the milk. Modern methods make it an easy matter to test the milk and ascertain the percentage of contained fat. The cheese made from

any lot of milk should be branded so as to show, with approximate accuracy, the quality of the milk and hence the composition (and presumable quality) of the cheese. Such a system of branding pure, whole-milk (or "full-cream") cheese would be simple and practicable, and would result in grading the cheese product in such a way as to show at once its relative merits, proper making and curing being assumed. The grade brand should give by a single numeral the nearest whole number indicating the percentage of fat in the milk of the cheese vat, and this fact and grade should be guaranteed by the maker. The margin of one-half per cent variation, or a range of 1 per cent of fat, would be entirely safe for the manufacturer and close enough for the merchant and consumer. For full-cream cheese there would be but three grades, 3, 4, and 5, giving a range of 2½ to 5½ per cent of fat, which is all that is ever found in large quantities of pure milk.

Such a system of branding and grading being adopted, there could be no objection to extending it to skims and part skims, adding three more grades, 0, 1, and 2. The preceding illustration and table relating to the six cheeses of the Wisconsin Dairy School show how this plan would operate. It would be easy to add a grade or two, as 6 and 7, for cheese of extra quality, like the English Stilton, containing an added quantity of milk fat.

LEGISLATIVE SAFEGUARDS.

If it be found that national legislation is the only method of meeting what seem to be the necessities of the case, to stop fraud and enforce honesty and intelligent dealing in connection with this important food product, it is certainly to be hoped that the subterfuge of a "revenue measure" need not be resorted to again. Yet this also may be necessary. In that case the leaning toward class legislation should be minimized by making any tax incident to the law merely nominal, unless, indeed, lard cheese, or all cheese, be regarded as a proper subject for raising revenue. It is believed to be a question for fair consideration whether all concerned would not be materially benefited if all cheese and cheese substitutes were to be taxed at a very low rate, branded and stamped, made, graded, and sold under United States internal-revenue laws, comprising some such system as outlined above.

As previously indicated, existing State laws already guard the interests of careful buyers to a large extent, and "afford incidental protection" to manufacturers in the principal cheese-making States. All buyers, whether merchants or consumers, should acquaint themselves with the brands and marks legally provided for cheese made in New York, Wisconsin, Ohio, Minnesota, and Colorado. The laws of other States hardly meet the requirements of the situation. These brands are seldom if ever actually counterfeited, although closely imitated,

as already described. The cheese makers and merchants in the States which provide and adopt these safeguards are entitled to reap the advantages which discriminating buyers can give them. General attention to this matter on the part of buyers would be likely to cause other States to adopt laws of proved efficiency, and, what is equally important, to provide for their proper enforcement.

In this connection a proposition recently originated in Wisconsin for a system of State trade-marks for food products and merchandise, to be authorized, copyrighted, and guarded by laws of Congress applying to interstate commerce, is commended as worthy of consideration. This scheme appears to come nearer to reaching the root of the evil than any yet proposed, and, being general in its nature, avoids the strong objections to measures which are regarded as class legislation.

One other point needs mention. Statistics given in table and diagram show that Great Britain has lately been reducing her imports of cheese from Canada as well as from this country. It is probably true that, with the immense quantities of extremely cheap mutton lately sent to British markets from Australia, this meat has been to some extent substituted for cheese. Therefore it may well be doubting whether the consumption of cheese in Great Britain and the consequent import demand will hereafter materially increase. This being the case, new markets should be sought for cheese made in this country. Canada is already on the alert and doing something in this direction. The United States can not follow this example too soon.

Cheese making is the least among the different branches of dairying in this country, in geographical distribution and in volume and value of product. Yet it is of much importance to this entire industry. It furnishes the safest and most convenient method of disposing of all surplus milk, and therefore serves as a sort of safety valve to dairying as a whole. Consequently all are interested in helping to stimulate the cheese trade, both domestic and foreign. All possible steps should be taken to vary and improve the offerings in our own markets, so as to increase home consumption and to reestablish a national reputation for honest cheese of uniform and high quality, in order to enlarge and extend our foreign trade.

CLIMATE, SOIL CHARACTERISTICS, AND IRRIGATION METHODS OF CALIFORNIA.

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THE RAINFALL.

The rainfall in California is exceedingly variable, ranging from a bountiful supply upon the high mountain summits to a small and uncertain quantity in the valleys. The greatest precipitation occurs in the northern portions of the State, about the heads of the Sacramento River, and the least in its extreme southern portions, where the average amount is about 3 inches annually.

It is to the snow and rain stored upon the mountain summits of California that the advanced and prosperous condition of its farmers and horticulturists is due, for while the State is annually visited in all its parts by a rainy season, the amount of precipitation, except in the extreme northern portions, is not sufficient for general crop production in the valleys, where the prime arable lands are to be found. Moreover, while these seasonal falls of rain are very variable, the years of least fall seem to occur at nearly regular intervals. The years of greatest fall do not occur with the same regularity. The following table of the seasonal rainfalls, from 1849 to 1890, from the observations taken at Sacramento and compiled by Sergeant Barwick, of the United States Signal Corps, very clearly shows these characteristics of California's rainy seasons:

TABLE I.—*Showing characteristics of seasonal rains in California.*

Rainy season of the year—	Total for season.	Rain for the month of—											
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1849-50	36.00	......	......	......	......	......	......	......	......	0.25	1.50	2.25	12.50
1850-51	4.71	4.50	0.50	10.00	4.25	0.25	0	0	0	0	0	Spr.	Spr.
1851-52	17.98	.65	.35	1.88	1.14	.69	0	0	0	1.00	.18	2.14	7.07
1852-53	36.36	.58	.12	6.40	.19	.30	0	0	0	Spr.	0	6.00	13.40
1853-54	20.06	3.00	2.00	7.00	3.50	1.45	Spr.	Spr.	0	Spr.	Spr.	1.50	1.54
1854-55	18.62	3.25	8.50	3.25	1.50	.21	0.31	0	Spr.	Spr.	1.01	.65	1.15
1855-56	13.76	2.67	3.46	4.20	4.32	1.15	.01	0	0	Spr.	0	.75	2.00
1856-57	10.46	4.92	.69	1.40	2.13	1.84	.03	0	0	Spr.	.20	.65	2.40
1857-58	15.00	1.38	4.80	.68	Spr.	Spr.	.35	0	Spr.	0	.66	2.41	2.63
1858-59	16.03	2.44	2.46	2.88	1.21	.20	.10	0.01	Spr.	Spr.	3.01	.15	4.34
1859-60	22.09	.96	3.91	1.64	.98	1.04	0	0	0	.02	0	6.48	1.83
1860-61	16.10	2.31	.93	5.11	2.87	2.49	.02	.63	0	.06	.91	.18	4.28

TABLE I.—*Showing characteristics of seasonal rains in California*—Continued.

Rainy season of the year—	Total for season.	Rain for the month of—											
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
	Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1861-62	35.56	2.67	2.92	3.32	0.48	0.59	0.14	0.55	0	0	Spr.	2.17	8.64
1862-63	11.58	15.04	4.26	2.80	.82	1.81	.01	0	0.01	0	0.36	Spr.	2.33
1863-64	7.87	1.73	2.75	2.36	1.69	.36	0	0	0	Spr.	0	1.49	1.82
1864-65	22.51	1.08	.19	1.30	1.08	.74	.09	0	.08	Spr.	.12	6.72	7.87
1865-66	17.93	4.78	.71	.48	1.37	.46	0	Spr.	0	0.08	.48	2.43	.36
1866-67	25.30	7.70	2.01	2.02	.48	2.25	.10	.02	0	0	Spr.	2.43	9.51
1867-68	32.79	3.44	7.10	1.01	1.80	.01	0	0	0	.01	0	3.81	12.85
1868-69	16.64	6.04	3.15	4.35	2.31	.27	Spr.	0	0	0	0	.77	2.61
1869-70	13.57	4.79	3.63	2.94	1.24	.65	.01	0	0	Spr.	2.12	.85	1 96
1870-71	8.47	1.37	3.24	1.64	2.12	.27	Spr.	Spr.	Spr.	0	.02	.58	.97
1871-72	23.65	2.08	1.92	.69	1.45	.76	Spr.	0	0	Spr.	.21	1.22	10.59
1872-73	14.21	4.04	4.74	1.94	.61	.28	.02	0	0	Spr.	.22	1.93	5.39
1873-74	22.90	1.23	4.36	.55	.51	0	Spr.	.02	Spr.	0	.31	1.21	10.01
1874-75	17.70	5.20	1.86	3.05	.89	.37	Spr.	Spr.	0	.05	2.26	3.80	.44
1875-76	26.53	8.70	.55	.80	Spr.	Spr.	1.10	0	0	0	.44	6.20	5.52
1876-77	8.96	4.99	3.75	4.15	1.10	.15	0	.21	.02	Spr.	3.45	.30	
1877-78	24.86	2.77	1.04	.56	.19	.64	.01	Spr.	Spr.	0	.73	1.07	1.43
1878-79	17.85	9.26	8.04	3.09	1.07	.17	0	0	0	.29	.55	.51	.47
1879-80	26.47	3.18	3.88	4.88	2.66	1.30	.13	Spr.	Spr.	0	.88	2.05	3.41
1880-81	26.57	1.64	1.83	1.70	14.20	.76	0	Spr.	0	0	0	.05	11.81
1881-82	16.51	6.14	5.06	1.37	1.64	Spr.	.50	Spr.	0	.30	.55	1.88	3.27
1882-83	18.11	1.89	2.40	3.78	1.99	.35	.10	Spr.	0	.57	2.63	3.22	1.13
1883-84	24.78	2.23	1.11	3.70	.67	2.85	0	0	0	.90	.96	.61	.44
1884-85	16.58	3.43	4.46	8.14	4.32	.06	1.45	0	Spr.	.60	2.01	0	10.45
1885-86	32.27	2.16	.49	.08	.68	Spr.	.11	Spr.	0	.08	.02	11.34	5.76
1886-87	13.97	7.95	.29	2.68	4.08	.07	0	0	0	0	.68	.21	2.21
1887-88	11.56	1.12	6.28	.94	2.53	Spr.	0	0	Spr.	.02	0	.45	2.09
1888-89	19.95	4.81	.57	3.04	.10	.40	.08	Spr.	Spr.	.55	0	4.28	4.63
1889-90	....	.15	.33	6.25	.26	3.25	.25	0	0	0	6.02	3.15	7.82
1890	....	6.62	4.06	3.00	......	......	......	......	......	......	......	......	......
Average..	19.58	3.78	2.80	2.95	1.86	.71	.12	.04	.003	.12	.80	2.14	4.61

NOTE.—The average of the seasons in the second column from the left of the table is for forty years, and the averages in the third, fourth, fifth, eleventh, twelfth, thirteenth, and fourteenth columns, counted from the left, are monthly averages for forty-one years; while the sixth seventh, eighth, ninth, and tenth are for forty years. Spr. means "Sprinkle."

In the foregoing table the rainfall is given for each rainy season, which includes parts of two consecutive years, as shown by the double dates in the first left-hand column. The second column from the left gives the total fall for each season, and the remaining columns give the amount of rain falling in each month of the seasons given by full numbers in column 1.

On inspection of column 2, it is seen that the falls for the seasons of 1850-51, 1856-57, 1863-64, 1870-71, 1876-77, 1881-82, and 1887-88 indicate very dry years, and that the intervals between them were six, seven, seven, six, five, and six years, respectively. The average of the intervals between the dry years during the entire period covered by the table is six years and two months. It is seen that these driest seasons are always accompanied by one or two moderately dry ones.

The average seasonal fall for the entire period was 19.57 inches. This quantity is near enough to be called 20 inches, and the table shows that in each of twenty-three years the rainfall fell below the average for the whole period, the mean amount for the deficient years being 14.19 inches, or about 5½ inches less than the total average. In each of seventeen years of the observed period the rainfall exceeded the general average, the mean for the seventeen years being 25.8 inches. This exceeds the annual average for the whole period of observation by 6 inches, and the average of the deficient years by nearly 12 inches.

Within the entire period the annual rainfall has exceeded 30 inches five times, varying from 32.27 to 36.36 inches, the latter fall occurring in 1852, and the rainfall has, in four years of the observations, ranged as low as from 8.96 inches to only 4.71 inches, the latter in the year 1850. Therefore the quantity of the seasonal rainfall at Sacramento has varied as much as 31.65 inches.

The bottom line of the table gives the averages of the rainfall for the whole period of observations, as before stated. The figures at the foot of the second column from the left-hand side show the average of the seasonal falls, and the remaining figures on this line, from left to right, give the average monthly falls.

It will be seen from a study of the monthly falls that the average rainy season for California extends from about the beginning of November to the end of April, a period of six months, and that the months from May to October, inclusive, are dry ones, the year being thus naturally divided into two equal parts, one rainy and the other dry.

The peculiarities of California rainfall, as shown by the Sacramento observations, while holding good to a greater or less degree for the entire State, are especially characteristic of the Sacramento and San Joaquin valleys and of the desert plains.

For the purpose of showing the range and variable nature of the rainy seasons in those valleys and on the deserts, the following table of the results of observations in California, compiled by the Chief Signal Officer and reported[1] to the United States Senate by the Secretary of War, is given:

TABLE II.—*Showing the range and variable nature of the rainy seasons in the Sacramento and San Joaquin valleys and on the deserts of California.*

Name of place of observation.	Greatest rainfall.	Least rainfall.	Average rainfall.	Period of observation.
IN THE SACRAMENTO VALLEY:	*Inches.*	*Inches.*	*Inches.*	*Years.*
Colusa	32.84	9.20	16.99	Fourteen.
Marysville	26.86	6.65	16.62	Seventeen.
Knights Landing	24.08	9.67	14.36	Ten.
Woodland	25.32	5.13	15.22	Fifteen.
Sacramento	36.36	4.71	19.57	Forty.

[1] Ex. Doc. No. 91, Fiftieth Congress, first session, 1888.

TABLE II.—*Showing the range and variable nature of the rainy seasons in the Sacramento and San Joaquin valleys and on the deserts of California*—Cont'd.

Name of place of observation.	Greatest rainfall.	Least rainfall.	Average rainfall.	Period of observation.
IN THE SAN JOAQUIN VALLEY:	*Inches.*	*Inches.*	*Inches.*	*Years.*
Stockton	22.04	6.87	13.91	Thirty-four.
Tracy	14.68	2.91	8.84	Seventeen.
Livermore	22.75	6.01	13.81	Do.
Modesto	13.54	2.25	8.89	Do.
Merced	30.83	3.03	11.75	Sixteen.
Fresno	16.62	4.87	8.79	Ten.
Visalia	13.10	3.95	9.25	Sixteen.
Tulare	11.65	3.07	6.64	Thirteen.
Delano	11.52	1.41	6.22	Twelve.
IN THE VICINITY OF RIVERSIDE:				
San Bernardino	37.51	9.98	16.17	Sixteen.
Colton	23.35	5.43	9.31	Eleven.
Riverside	22.54	2.94	9.37	Six.
Los Angeles	32.16	3.97	16.03	Sixteen.
San Diego	25.97	3.71	10.26	Thirty-seven.
DESERT STATIONS:				
Mojave	9.96	0	4.05	Eleven.
Daggett			3.97	One.
Needles			6.17	Do.
Indio	.62	0	.12	Ten.
Fort Yuma	7.04	.85	3.40	Thirty-six.

The average of the fourth column from the left-hand side of the table for the Sacramento Valley is 16.55 inches; for the San Joaquin Valley, 9.79; for the vicinity of Riverside, 12.23, and for the desert stations, 3.54.

The foregoing tables show very clearly that the valley lands of California here described have a dry climate and should be classed as arid. That their owners so classify them, from Colusa, in the Sacramento Valley, southward, is seen in the efforts made to bring them under some system of irrigation. These lands, in a state of nature, are devoid of pasturage away from the banks and low-lying lands along the main streams, and put under cultivation can be made to produce a wheat crop only about once in three years. The practice is to crop the land one season and let it lie fallow the following one, but it often happens that the third season is so dry as not to produce a crop. Wheat raising is, therefore, an uncertain and usually disappointing business in these valleys when made to depend upon the natural rainfall for its success. The meager yield of an acre of wheat, even at its best, leads to large land holdings, that the quantity secured may be sufficient to make the business profitable.

CHARACTER OF SOIL OF DISTRICTS WHERE IRRIGATION IS PRACTICED.

The districts of California in which the practice of irrigation is attended by the largest results are the orchard regions, ranging from Woodland, in Yolo County, to Stockton, in San Joaquin County.

These include the region about San Jose, in the Santa Clara Valley; the Fresno region and Kern County, in the San Joaquin Valley, and the Riverside district, in the valley of the Santa Ana.

The first-mentioned district, extending down the valley of the Sacramento to the bay of San Francisco, and thence up the San Joaquin to Stockton, possesses a very rich, deep, alluvial soil in all its lower portions along the margins of its river channels, which soil spreads out widely along the shores of the bay. The surface of these valleys rises on a gentle grade from either side of the river channel toward the foot of the mountains, and this grade has an increased rate of inclination as the surface nears the foot of the mountain slopes. As the valley surface rises the alluvial soil gradually gives way to soil washed down from the mountain slopes. This consists of quite a large proportion of clay, containing vegetable matter, with sand and gravel intermixed with it. This soil is in general called by the Mexican name "adobe." It readily soaks full of water, aided by the sand and gravel it contains, and as soon as the surface dries it becomes "baked," and is then about as hard as the "soft-burned" brick of our kilns.

The first of the districts mentioned as lying in the lower portions of the Sacramento and San Joaquin valleys, not having enough rain to insure the common range of agricultural crops, is largely devoted to fruit production, with occasional wheat crops. The fruits produced are the peach, plum, prune, apricot, cherry, grape, and the common range of small fruits.

The orchards are irrigated by means of windmills pumping from wells, in which water is reached at a depth of from 12 to 14 feet. The quantity of water used varies from 11,000 to 12,000 cubic feet a month during the four driest months of the summer. The total amount applied is sufficient to cover the land irrigated 13¾ inches deep in that time. In some cases, where steam is employed to do the pumping, the land so irrigated is covered 3 feet in depth during the growing season, with a manifest advantage in growth of trees and crop yield.

In the region of San Jose the soil is a strong "adobe," with much gravel and sand, constituting a prime fruit land. The whole region is devoted to the production of the same range of fruits as before described. The water used in irrigation here is pumped by steam power from a depth of about 80 feet, and the quantity used in four months (from May to August, inclusive) would cover the land 16 inches deep. In 1892 this section was visited by a heavy rainfall, amounting to 35 inches, and yet there were orchards in which 16 inches more were added by irrigation, with the result that those so treated yielded, by careful measurement, 33 per cent more fruit than did those alongside of them which were not irrigated.

In the Fresno region, which includes Kern County and the Bakersfield districts, a large range of soils is to be found, varying from rich, black, sandy alluvium to almost pure clay, without sand or gravel in

its composition. The richest of these soils is found along the middle and upper portions of the Kings River and Kern River deltas. West of these, in the central portions of the San Joaquin Valley, the adobe clays predominate and border the marshy lands which extend around Lake Tulare; eastward from the deltas, among the foothills, a red clay is plentiful.

AMOUNT OF WATER USED IN IRRIGATION.

Thirty years ago, when the first settlement was made where now stands the town of Fresno, well water was obtained by digging 60 to 80 feet deep. Since that time the water of Kings River has been brought out over the delta for irrigation purposes, the effect of which has been to fill up the subsoil to such an extent that over a very large area the ground water is within a few feet of the surface, and in order to have dry cellars in the town they must be cemented. The old wells, 80 feet deep, are now full of water to within 6 feet of the surface. This condition of the subsoils of the delta has brought about a great change in the method of irrigation, and has greatly lessened the quantity of water used for that purpose. At first the dry soils took the large amount of a miner's inch per acre, applied throughout the year. This is equal to one cubic foot of water a second applied to 50 acres during the entire year, which quantity would cover that amount of land 14 feet 5¾ inches deep in that time, and then it no more than sufficed for the purpose of crop production on those thirsty soils. Now, with few exceptions, the water is not applied all over the surface, but is allowed to seep through the soil from ditches alongside of or passing through the fields. This is very effectual in all the sandy alluvial soils of the region, and the quantity used is very small, for it is estimated by those who are capable of judging that 1 cubic foot a second now suffices for the irrigation of 500 acres.

In Kern County and about Bakersfield much very sandy soil is found, and on the north side of the ancient channel of Kern River there is the same character of subsoil as in the case of the Kings River delta. Here also, when the region was first settled, well water was only to be had by digging about 60 feet for it, while now, after about twenty-five years of irrigation of the surface, the ground water ranges only 12 to 20 feet below the surface about Bakersfield. West of that town from 7 to 12 miles it has in many places come to the surface. Where such is the case no irrigation is needed for orchards that are on ground 5 or 6 feet above it. Quite the contrary condition exists over all the irrigated country to the south of the old river channel, for no ground water has ever been found under it at any reasonable depth, nor does the subsoil fill at all by reason of the irrigation of the surface. Hence the maximum quantity of water is used in the irrigation of these lands, amounting to as much as a cubic foot per second to 100 or 150 acres.

The maximum quantity applied to the lands on the north side of the old channel is 1 cubic foot a second to 250 acres, the supply supposed to be continuous throughout the year, and this will cover 250 acres 34 inches deep in that time. The former quantity stated as applicable to the south of the old river channel in the same length of time will cover 100 acres 87 inches deep and 150 acres 58 inches in the space of one year.

The agricultural and horticultural products have a wide range, the principal being wheat, oats, barley, corn, potatoes (two crops a year), alfalfa (six crops a year), pears, cherries, peaches, apricots, plums, prunes, raisins, table and wine grapes, olives, and figs. Citrus culture is not far advanced, but a good beginning has been made.

The Riverside district is the leading orchard region of the State, owing to the wide area developed in such cultivation. It comprises a great extent of country, ranging from Los Angeles eastward to Beaumont and Benning, and from San Bernardino southward to San Diego. The soil of its valleys is very sandy, much of it being a rich, black, sandy loam. That of the bluffs and high table-lands bordering the valleys consists of adobe clays, with a mixture of sand and gravel.

In the Redlands district the soil consists of a stiff red clay, with a coarse, sharp granite sand intermixed. It is from the color of the soil that the town derives its name. In general, the subsoils of this district consist of clays, gravel, and sand, in varying proportions, but with a very open texture, so that the high lands are deeply underdrained.

About the town of Riverside much light sandy soil is found, and this characteristic occurs in many other places on the high lands. As the light soils alternate with those of heavy clay, these conditions have led to the use of varying quantities of water in irrigating them.

The sandy soils take up the most water, and the clayey ones the least, the former parting with it the most rapidly, and therefore needing the most frequent application of it. A cubic foot per second is applied to 150 acres, which would cover that area 58 inches deep in one year. This is the allowance for the light sandy soils, while the heavier soils receive the same quantity of water to each 250 acres, a year's supply at this rate covering that area to a depth of 34 inches.

As will be seen by an inspection of Table II, the rainfall of this district varies greatly. San Bernardino has the greatest amount, a fact which is due to the close proximity of the high snow-clad peaks of the mountain range, which derives its name from the town. At Los Angeles is the next greatest fall, due to the close approach of the Pacific Ocean to that point, with no intervening mountain range.

For the interior of this district the rainfall ranges at about the minimum of the table. Small as it is, 10 inches or less, it is considered very valuable to the farms and orchards, notwithstanding the amount of water used upon them artificially. It falls during the

rainy months, as shown by Table I, and its good effects extend to the following June. When deficient, as it sometimes is, the want is seriously felt.

The principal agricultural products are wheat, barley, potatoes, beans, sugar beets, alfalfa, and common garden crops; the horticultural are oranges, lemons, limes, peaches, apricots, nectarines, grapes, cherries, plums, raisins, olives, English walnuts, and the hard and soft-shelled almonds.

HOW IRRIGATION IS PRACTICED.

For the spreading of the water in the process of irrigation there are in California four methods in use. These are (1) by flooding, (2) by basins or checks, (3) by furrows or ditches in place of the checks, and (4) by furrows run in a parallel system.

In all these methods the water to be used must be brought in the main ditch to the highest side of the field which is to be irrigated, and taken from the main by notches cut in its side.

Irrigation by flooding.—For the purpose of the first method, the water from these notches is conducted over the surface of the field by helpers, who are furnished with long-legged rubber boots and long-handled shovels. Their business is to wade into the flood of water as it flows along and cause it to spread evenly over all the surface of the field. This is done by putting, by means of a shovel, little dams across the current when it flows too freely, and removing clods and slight ridges which obstruct it. This is a work requiring great watchfulness to prevent the water from cutting channels in the field, which danger increases with the slope of its surface, and also to avoid the leaving of dry spots, for unless these be very small in diameter, they will receive no benefit from the irrigation, owing to the tendency of the water to pass into the earth in perpendicular lines and not to spread horizontally to any considerable extent.

The quantity of water used in this method of irrigation must be large enough to cause a flow across the entire field. If it can not be had in sufficient quantity for this, then the field must be divided into sections by laterals from the main ditch, so that the quantity which can be used will be sufficient to flood the sections completely in succession. For the reason that quite a large proportion of the water used in this method is liable to be lost as wastage at the lowest sides of the field, it is prudent to begin, in the case of a divided field, with the uppermost section, in order that the surplus may be carried into the next lower lateral and added to the quantity which will be let out of that lateral upon the succeeding lower section, and so on.

When, in flooding the land, the plan by sections is used, it saves much of the water which is lost by working without them, for the reason that the operator can graduate the quantity applied, making it less and less, as the successive sections are flooded, by the amount

of the surplus which comes down to them from the upper ones. The lowest section will need but a small amount over the surplus coming to it from above.

While this method is the most wasteful of the water used, it is considered by all who have had large experience in such matters to be the most effective of all plans for irrigation, as well as the cheapest.

Irrigation by basins or checks.—The basin plan is used on flat surfaces, where there is not enough slope to cause the water to flow readily in a thin sheet over the land, as in flooding or along furrows.

It is largely used in the irrigation of the cereals and of orchards, and can be applied to surfaces where the slope is not over 2 feet fall in 100 and should be used where a large quantity of water must be held upon the land until it soaks into it.

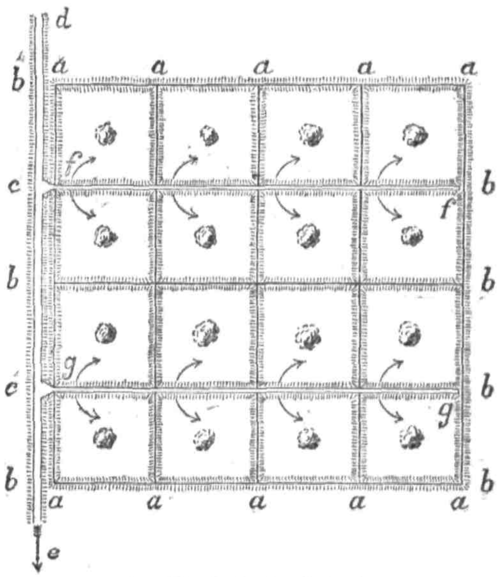


FIG. 123.—Irrigation by basins.

Fig. 123 shows the application of this method to the irrigation of an orchard; *d e* is the main ditch located on the highest side of the orchard, the slope of which is from left to right of the figure; *b b*, *b b*, *a a*, *a a*, etc., are solid embankments about a foot high, in this case, made by backfurrowing three furrows together with a plow, and then shaping them up smooth and true with a shovel; *c b* and *c b* are such ridges with a ditch made in the top of them, along which the water flows from notches *c c* in the main ditch, and is let into the square basins formed by the system of embankments through notches at the points marked by the curved arrows. The water is made to flow through these notches by means of a shovelful or two of earth thrown into the ditch in the form of a dam. The irregular-shaped dots in the center of the basins represent the orchard trees.

This method is used when large quantities of water are to be put upon lands, sometimes to the depth of 4 or 5 feet, as in upper Egypt, where the clear water of the Nile, on its first rise, is used to dissolve out of the surface soil the salts which accumulate between the cropping seasons. The surcharged waters are turned out of the basins into the river, and then the basins are filled with the muddy waters of the high flood, the slimy deposit from which furnishes fertility to the crops. Each of the basins so used incloses thousands of acres.

Irrigation by ditches.—Fig. 124 shows a modification of the basin plan, as applied to ground with considerable slope and consisting of hillside land, wherein *f m* is the main ditch on the highest side of the field, of which *b c d e* mark the boundaries. Its surface slopes in the direction of the arrows; *o o* and *q q* are "check levees," or slight embankments, built on level lines around the curved surfaces of the field. A supply ditch, *i j*, leads the water into the "checks" or basins *b c*, *o o*, and *q q*, etc., and *t w l* is a waste ditch for discharging the surplus water from the checks when no longer needed. The "check levees," *o o*, *q q*, are usually constructed so as to be about 6 to 12 inches high, and sometimes higher.

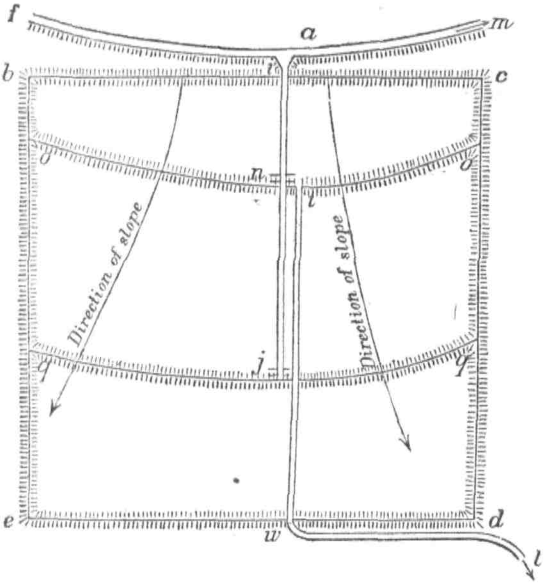


FIG. 124.—Irrigation by checks.

Fig. 125 shows the second method of spreading the water over a hillside field, in which, as in fig. 124, *f m* is the main ditch and the slope of the hill as shown by the arrows; *t o*, *r p*, and *s q* are small ditches or plow furrows cut on a level line around the face of the hill. The water is let into the field by the short ditch at *i*, and is then spread over the space *b c t o* by means of a marginal ditch *y z*, from which it is made to flow in small streams and in a regular manner over the space between it and the lower ditch *t o*. This is done by men wearing rubber boots and furnished with shovels as in the first method. The surplus water runs down to the ditch *t o*, and is caught by it and held until it is full and the water

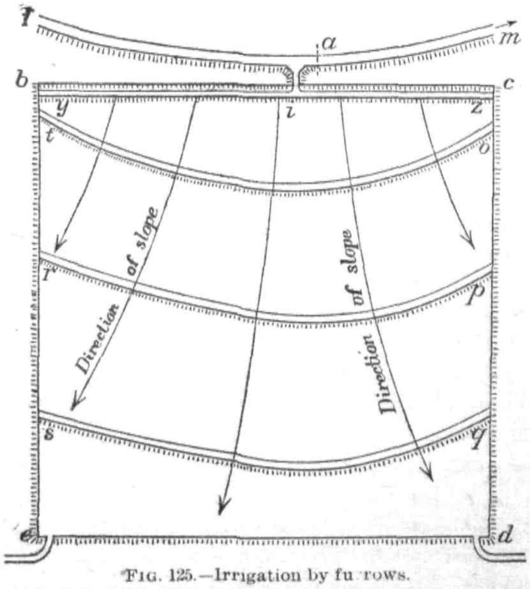


FIG. 125.—Irrigation by fu rows.

runs over, which it will do all along *t o*, as it is level from end to end. It is now the work of the irrigationist to cause it to spill evenly across the space *t o r p*, covering every part of it as in the case of flooding first described.

This operation must be done by causing the water to flow very slowly from one spreading ditch to the other over the whole field, and the supply at *i* must be shut off before the flowing water has quite reached the lower side of the field *e d*. If this is not done at the right time, the loss by wastage may be very great. At *e* and *d* in the figure are represented two waste ditches, whereby the surplus water may be discharged from the field.

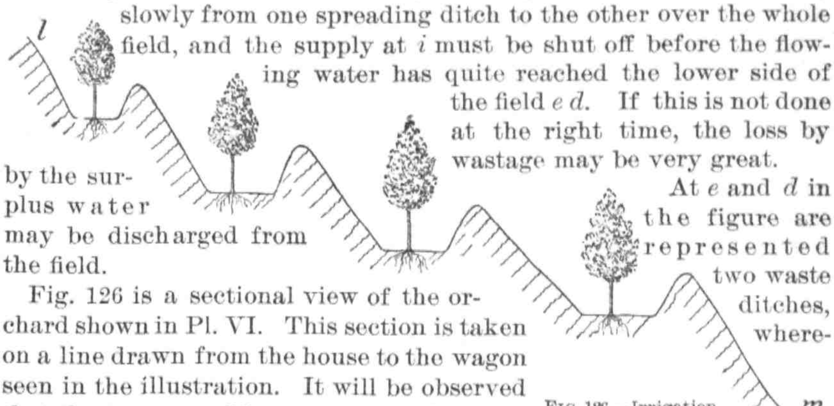


FIG. 126.—Irrigation by means of check levees for orchards on sloping hillsides (sectional view).

Fig. 126 is a sectional view of the orchard shown in Pl. VI. This section is taken on a line drawn from the house to the wagon seen in the illustration. It will be observed that the trees stand between embankments, the object of which is to hold water applied in irrigating them until it soaks into the soil about their roots. This is the only method by which sufficient quantities of water can be applied to steep sidehills long enough to accomplish the purposes of irrigation. The plan is the same as that shown in fig. 124.

Fig. 127 is a section of the hillside also shown in the same plate, beginning at the left side of the picture and running down to the wagon, and shows the method of irrigating steep slopes by terraces. The water is brought to the highest part of the hillside to which it is to be applied; the sidehill being cut into a regular system of level terraces, each bench having a small ditch at the foot of the slope on the inside, and a slight embankment on the outside of it. The ditch catches the water as it comes trickling slowly down the steep slope above it and causes it to spread evenly over the level bench, and the little ridge on the outside of this bench holds the water back for a time until it has sufficiently soaked into the soil. Care must be taken not to allow the water to cut channels on its way down over the steep slopes of this system.

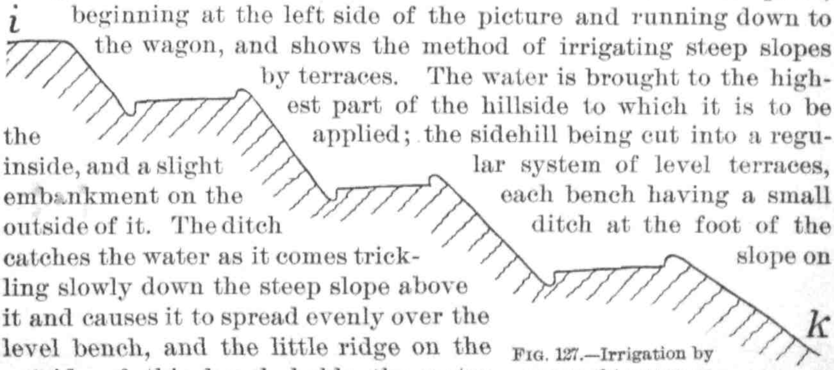


FIG. 127.—Irrigation by means of terraces on steep hillsides (sectional view).

Irrigation by furrows.—The fourth method, by furrows, is used largely in the irrigation of orchards, and is applicable to all crops planted in rows. The furrows are usually made with a plow; there are some contrivances by which several furrows can be made at once.

For orchards it is usual to make the furrows 2½ feet apart from center to center and to make the system cover all the space between the rows of trees, going one way through the orchard to within 2½ feet of the trees on either side of the space furrowed.

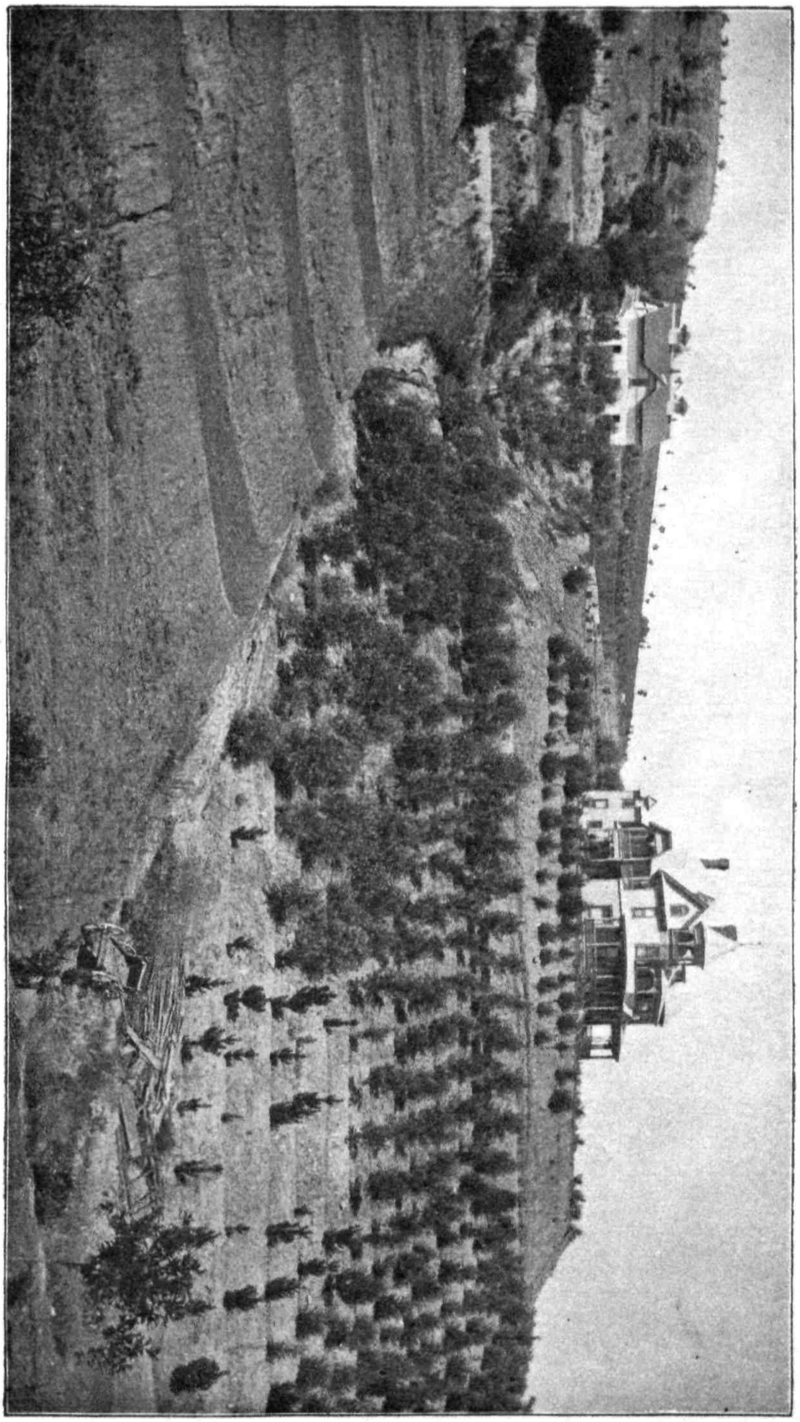
In case of other crops and gardens, the number of furrows and their distance apart will be governed by the distance between the rows of plants. This is the most simple and economical method in the use of water for irrigating purposes, and is the one to use in all cases in which the water supply is small. The furrows are filled with water from end to end. That this may be done, they must be level throughout their extent. When the supply given them has been absorbed by the soil, another can be given them, and so on until the proper quantity has been furnished.

In all these methods the field irrigated should have a border embankment thrown up all around it on its boundary line, to prevent the water from escaping to the lands adjacent, in which case it might cause serious damage. Then, too, there should always be provided an escape ditch through which the surplusage can be carried off to a stream or waste canal. (See Pl. VII.)

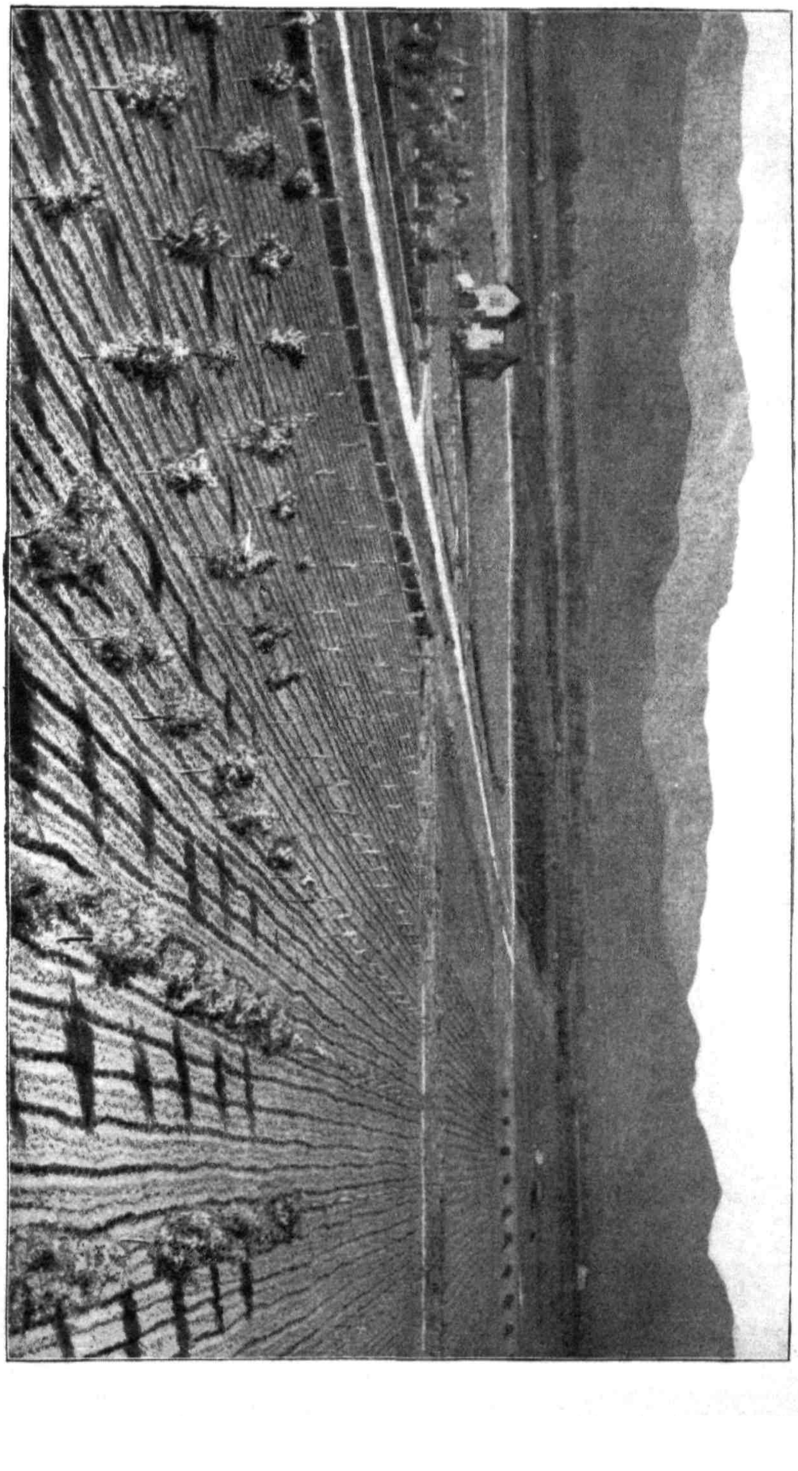
It is usual among irrigationists to use the term "irrigating head" when speaking of the quantity of water to be handled in irrigating a given field.

It is found in practice that the smallest quantity of water that can be made to flow far enough to be useful is one-half a cubic foot a second. This quantity is chiefly applied to the irrigation of gardens and very small fields. For field irrigation the quantity for one man to "handle" varies from 1½ to 6 cubic feet a second, which quantities would be called one and four irrigating heads, respectively.

The average of the usage in this regard is about 1½ cubic feet, or one irrigating head, a second. After the water has been applied in any case, and the soil has come into condition to permit of it, a careful and thorough cultivation of the surface must be given. In the case of most soils this is imperative, in order to prevent "baking," that is, a hardening and drying by the sun's heat; also to prevent undue evaporation, which a finely pulverized condition of the surface holds well in check. Such cultivation also keeps the ground clear of weeds, which otherwise grow rapidly on irrigated lands.



PLAN OF IRRIGATION BY TERRACES SHOWN AT THE LEFT OF THE RAVINE AND AN ORCHARD IRRIGATED BY CHECK LEVEES ON THE RIGHT OF IT.



FURROW SYSTEM OF IRRIGATING AN ORCHARD IN CALIFORNIA.

COOPERATIVE ROAD CONSTRUCTION.

By Roy Stone,
Special Agent and Engineer, U. S. Department of Agriculture.

COMMUNITY OF INTEREST IN ROAD CONSTRUCTION.

Current thought and feeling in the United States regarding the improvement of highways is setting steadily toward a recognition of the common interest of all classes of citizens, wherever located, and of all capital, however invested, in good roads.

The constantly increasing use of country roads by city people, or for their benefit, develops and demonstrates this community of interest on the part of the citizen. The common interest of all capital in the subject is well expressed by the following utterance of the Chamber of Commerce of the State of New York:

> The movement for good roads deeply concerns every commercial and financial interest in the land. We are handicapped in all the markets of the world by an enormous waste of labor in the primary transportation of our products and manufactures, while our home markets are restricted by difficulties in rural distribution which not infrequently clog all the channels of transportation, trade, and finance.

The community of interest in the subject being recognized, methods of cooperation in road construction and the proper distribution of the cost thereof, become the ruling questions in the discussion of highway improvement.

NATIONAL AND STATE AID.

In Europe the public interest in highways is so well known that most of the roads have been built directly by national expenditure and are maintained either wholly or partly by national appropriations.

In the early days of this Republic the national concern in road improvement was so well understood that a great system of national roads, twelve in number, was laid out, and more or less work was done upon nearly all of them, although the Cumberland road was the only one finished when the financial crisis of 1837 prostrated all private and public enterprises.

Among the States, Kentucky took an early lead in cooperating with counties, municipalities, and private capitalists in the construction of turnpike roads. The State contributed about $1,750,000 to seven of the leading thoroughfares, coving 640 miles, and this was only a portion of its total expenditure. In the years 1837 and 1839 the State

had in its employment an engineering corps, principally engaged in road work, costing an aggregate of $31,675 per year. These improvements covered only a trifling percentage of the total mileage of roads in the State, but they have been of such value as to make the State conspicuously prosperous for the last half century.

The State of Ohio, observing the advantages of good roads to her neighbor, has followed with very extensive road improvement, mainly upon the cooperative plan, in which the county pays a portion of the cost and the property within one or two miles of the road is assessed for the remainder. Under these or similar provisions, about one-eighth of the total mileage of roads in the State has been improved.

The most noticeable and extended cooperative work, however, has been done in New Jersey, under the State-aid law of 1891. Under this law the property owners along any line of road are assessed 10 per cent of the cost, and in addition to this the State contributes one-third of the total cost, and the county is compelled to furnish the remainder and to construct the road. This law has been so effective that the appropriation has been almost annually increased and the demand for construction under it has many times exceeded the funds available. It has, moreover, created competition for the benefits of State expenditure, and in that way has promoted discussion and education in regard to road improvement more rapidly than any other system.

The progress of New Jersey in this direction has been watched by other States, and it may safely be said that the course of legislation in all the States which are studying the question is toward the adoption of this method of cooperation.

That the State of Massachusetts has adopted a different system is probably due mainly to the nonagricultural character of the State. There it is necessary that roads be built to connect manufacturing towns and districts where the property along their lines is of little value for agriculture and the interest of the Commonwealth is independent of any agricultural conditions. The State has therefore taken upon itself the entire burden of building the principal roads throughout the Commonwealth, though it ultimately requires the counties to pay one-fourth of the cost.

Connecticut has taken up the cooperative method upon the scale of an equal distribution between the State, county, and the district. The towns in New England having complete government, the policy of the Massachusetts State road commission has been to place all contracts for road construction in the hands of the town authorities, to be executed by town officials. The effect of this plan has been excellent.

Whatever profit may be derived from the construction becomes a public fund instead of going to a private contractor, and the officials become thoroughly trained in road construction under the supervision of the State engineering force.

The State of Rhode Island has also fallen into line for cooperation, but includes with the State only towns and cities, leaving out the counties, and leaves the division of the cost to be prescribed by the general assembly of the State. The State, moreover, undertakes to build sample roads, not exceeding one-half mile in length, in any town, as an educator to its citizens, and the towns are liable to the State for one-quarter part of the expense of construction.

California has still another method of cooperation. The State furnishes the services of a highway commission of three experts, whose entire time is devoted to the supervision of road construction, and it further provides for the erection and operation of rock-crushing plants at the State prisons, and the distribution of the prepared road material to the counties at the bare cost of the maintenance of the convicts and the incidental expenses of their work. It has, moreover, arranged with the principal railroads in the State to transport this material at the cost of carriage.

LEGISLATION FAVORING THE COOPERATIVE SYSTEM.

In the legislation pending in other States the principal feature is the endeavor to perfect the cooperative system, and in this the States of New York and Virginia are conspicuously leading.

The assembly of the State of New York, having in the spring of 1894 sent a strong committee to study the New Jersey road system, passed, almost unanimously, an act to provide for the construction of roads by local assessment, county and State aid. Section 1 of this act provides as follows:

PETITION OF BORDERING LAND OWNERS FOR SURVEY AND ESTIMATE OF COST OF LOCAL ROAD; SUBSEQUENT PETITION OF RESIDENTS OF BENEFIT DISTRICT.

On presentation to the board of supervisors of any county of a petition signed by the owners of not less than one-third of the lands bordering on any section of road already established or proposed to be established in such county asking for a survey and estimate of the cost of building or rebuilding such road in a substantial and permanent manner either of stone or gravel as prescribed in such petition, such board of supervisors shall cause such survey and estimate to be made for the information of such petitioners and shall forward a copy thereof to the State engineer. Whenever thereafter the petitioners shall present to such board of supervisors a map or description of the lands which, in their opinion, will be directly benefited by the construction or improvement of such road, together with a written request of the owners of three-fifths of such lands that all the lands so benefited and the personal property in such district be assessed, in proportion to the benefits conferred for such construction or improvement, to the amount of one-third of the total cost thereof, such board of supervisors shall cause such road to be constructed or improved. Such lands so mapped or described shall be known as the benefit district of the said section of road. But whenever the original petition in any case shall set forth that the area to be benefited by the road is peculiarly restricted by the proximity of other roads or by other circumstances, an examination and report shall be made by the supervisor of the town and the surveyor of the road, and if it appears thereby that such area is less than 2 square miles

for each mile of the road to be built, then the proportion of cost required to be paid by the benefit district shall be diminished at the rate of 3½ per cent of the whole cost for the first 100 acres of such deficiency and 3 per cent for each additional 100 acres of such deficiency, but shall in no case be less than one-tenth of the whole, and the balance of the cost of such construction shall be equally borne by the county and State.

This provision differs from the New Jersey law in extending the local assessment to cover not merely the abutting lands, but, as nearly as can be ascertained, all the lands benefited by the construction of the particular road in question, and in increasing the total local assessment to one-third instead of one-tenth the cost of the road, making exception, however, in cases where benefits are peculiarly restricted by the proximity of other roads or by other circumstances.

Whenever counties are able to decide upon a highway system and a general and extended provision of funds by bonds or otherwise for construction, they will be able to secure State aid without the machinery and complications of a local initiative. Whenever the county fails to do this, any town in the county may initiate road improvement for the whole town, or for any portion of it, and receive the *modicum of State aid; but where county and town both fail, by reason* of local jealousies or lack of interest, to provide for improvement, any enterprising neighborhood may proceed at once to organize its benefit district and have its road constructed.

The plan under consideration in Virginia, as formulated by the State Road Improvement Association, limits the local charge for the entire benefit district to 10 per cent and the State contribution to 25 per cent, leaving upon the county 65 per cent of the cost; but it does not, as in New York and New Jersey, compel the county to construct the road upon application, unless it has the funds available for doing so or decides by a vote of three-fifths of the freeholders to raise them by the issuance of bonds.

Both New York and Virginia provide for distributing the local charge over a term of years at the individual option of the payers. The effect of this distribution, over five years in the Virginia plan, and ten years in the New York plan, diminishes the annual tax for the improvement, so that it will be but little felt.

BEST ROAD FOR FARMING DISTRICTS.

It is generally conceded that the best road for the farming district is a narrow stone road with an earth road alongside. Such a road has been built in Canandaigua, N. Y., for less than $1,000 per mile, and in other places for less than $1,200.

Supposing the average cost of such a road to be $4 per rod, or $1,280 per mile, and the benefit district to average 1 mile on each side of the road, and supposing the district is charged with one-fourth of the cost, $320 per mile, this would be only 25 cents per acre on the lands benefited, or 5 cents per acre annually, if distributed over five

years. This amount is less than half the ordinary road-maintenance tax, and, as the improved road becomes a county road and is maintained at the county expense, the amount required for the maintenance of other roads in the district would be reduced accordingly, and the total tax might not be increased at all.

The increase in taxable values due to road improvement will, as it has in all cases heretofore, prevent any necessity for raising the tax rate, except perhaps temporarily.

USE OF CONVICT LABOR.

The very successful use of convict labor in North Carolina, and its partial success in some other States, together with the initiative taken in California, has led to the discussion of a more elaborate plan for cooperation by the use of convicts, and the many difficulties found in the employment of convict labor in competition with skilled mechanical labor are directing public attention to this plan in many States.

The plan proposed for this is, in substance, for the State to buy or lease some of the best quarries of road material within its limits; to make the necessary railway connections, having first secured the permanent agreement of all the leading railway companies to carry road materials at the bare cost of hauling, on condition, if required, that the State shall furnish to them a certain amount of track ballast made from the inferior rock of the quarry; to erect the necessary buildings and stockades and provide the best machinery for quarrying and crushing the rock; to bring to the stockades all able-bodied State convicts and put them at this work, the counties to put their jail prisoners and tramps at the work of grading, draining, and preparing the road for macadamizing; and to furnish the crushed stone free on board cars as its contribution to road improvement.

Upon this plan the cost to the State in addition to the maintenance and guarding of the convicts, which is a necessary expense in any case, would be only that of the fuel and oil, explosives, use of machinery, etc., required for carrying on quarry work. This expense, according to the report of the Massachusetts commission on highways, amounts to 6.8 cents per cubic yard of broken stone produced. The amount of broken stone required to lay a mile of single track 9 feet wide and 8 inches deep is, in round numbers, 1,200 cubic yards, and would cost at this rate $81.60.

The remaining cost would be the railroad freight, amounting, for an average distance of 100 miles, to not more than 28 cents per yard, $336; the wagon haul, averaging possibly 2½ miles, 30 cents per yard, $360; and the rolling, superintendence, and incidentals (not including engineering, which would be a general county charge), 10 cents per yard, making the total cost, exclusive of the first cost of the stone, which is borne by the State, 68 cents per cubic yard, or $816 per mile.

The wagon haul is estimated on the basis of the country price of

$3 per day for team and driver, and of hauling (over the hard road as it is made) 2 cubic yards at a load, and an average travel for a team of 25 miles a day.

This plan brings the expense of road improvement so low that no elaborate scheme of taxation, bonding, or borrowing would be necessary, and all its benefits could be speedily and universally realized. The best plan for carrying it out would, perhaps, be to let the "benefit district," as heretofore defined, pay one-third of the cost, by installments, and the township one-third, the county to pay the remainder and to advance the amount for the district, with a rebate or discount to all individuals who preferred to pay in cash, so that no one would be put in debt against his will.

The cost to the district on this basis of division would be $272 per mile. Taking the average width benefited at 2 miles, or 1,280 acres for each mile of road, the total charge per acre would be 21 cents, or 3 cents per acre annually if spread over seven years.

COOPERATION NECESSARY.

Heretofore the cost of country roads has been borne by the farmers alone, and no method has been provided whereby the people in towns could contribute thereto. These people are now becoming thoroughly convinced of their interest in country roads, and in many cases are even more willing than the farmers to aid in road improvement.

The best plan for starting an improvement is that of the local initiative, or benefit district, plan. County road laws have been passed in many States, but they involve the education of a whole county before any work can be begun; but in every county some neighborhood will be found prompt to avail itself of the opportunity to secure road improvement upon contributing a portion toward its cost.

In some States towns have been authorized to issue bonds for road improvement and have done so successfully, but have necessarily paid a higher rate of interest than a county or State would do.

The benefit district, as described in the New York plan, being self-defined and of absolutely identical interest, forms the ideal unit for initiating road construction. Any larger district, as a town or county, containing a number of roads, is liable to be divided by local interests and jealousies, but the users of any *one* road can have no cause for division of interest.

The benefit district includes, without question, all the users of the section of road in question, and the extent of their individual use of the road can be approximately ascertained, and when ascertained forms the most equitable possible basis for the division of the local share of the cost.

A PIONEER IN AGRICULTURAL SCIENCE.

By W. P. Cutter,
Librarian, U. S. Department of Agriculture.

AGRICULTURE IN COLONIAL VIRGINIA.

The existence of the colony of Virginia was dependent to a great extent on the cultivation of a single agricultural product, tobacco, which was not only the staple crop of the colony for nearly two centuries, but served as a medium of exchange and as the basis for governmental support by taxation. Soon after the founding of the Virginia settlements, a decree of the English King, James I, legitimized the tobacco trade, and every available piece of ground in the village of Jamestown was at once planted to tobacco. The enormous profits made by the planters attracted large numbers of settlers; new lands were cleared, and growing tobacco soon covered them.

The agriculture of colonial Virginia was extremely crude in character. The staple food crops were cultivated only to the extent necessary to provide food for the laborers employed in tobacco cultivation, which was the main end to which everything else was subordinated. Although the colony became very prosperous as a result of the enormous demand for tobacco and the comparatively slight cost of raising the crop, much of the depression which followed the war of the Revolution may be ascribed to the continuous growth of this one crop for such a long period of time. The operations of the farm were so similar in character from year to year that little attention was paid to the details of farm management by the planters themselves, who spent the major part of their time in the exercise of the rites of hospitality, even now so proverbial a characteristic of Virginians. The agricultural interests of the State suffered from this lethargy of the most intelligent of her citizens, being left in care of plantation overseers, who were often not much less ignorant than the slaves whose labors they superintended.

With the war of the Revolution came the interruptions to commerce incident to the struggle. The profits of tobacco culture being suddenly decreased, more attention was paid to the raising of other crops. With the outbreak of the French Revolution and the wars which followed, the demand for cereals became so great, the price rising in proportion, that every planter abandoned his tobacco fields to the cultivation of food stuffs; but the soil, although fertile in the beginning,

had so long been subjected to the exhausting demands of the tobacco crop that the yield of wheat was small.

In the early history of the colony, land was plentiful. When a field ceased to yield profitably, it was an easy matter to use the laboring force during the comparatively idle winter season in clearing new land for cultivation. A time came, however, when the land covered by the original forest was scarce, and the fertility once present had been reduced by exhaustive cropping. The great profits of the past had disappeared as a result of careless management. The demand for cereals decreased with the universal peace which succeeded the fall of Napoleon, and the planters of Virginia found themselves confronted by very depressing conditions; a period of comparative stagnation ensued. Some of the farmers had made attempts to introduce cotton cultivation without great success. Tobacco raising was confined to a large extent to the upland counties, where the land was less exhausted and where special methods of curing still made the crop a profitable one; but in the eastern and middle section there seemed to be no possible method of regaining the former prosperity. Many of the old Virginia families, attracted by the marvelous tales of the fertility of the newly settled prairies of the West, deserted their ancestral homes and sought new fields for their efforts. The price of land decreased, and taxes increased in consequence.

CHARACTERISTIC CONDITIONS AND INFLUENCES.

The general process of development in the United States was modified in the South by special influences. The institution of slavery had formed a distinct social system, the dominant class becoming a proud aristocracy. There was ample leisure for self-improvement, and the standard of culture was high. The standard works were widely read, and newspapers were abundant; a few magazines of great intellectual excellence but meager circulation were issued. Scant encouragement was given to those who chose the literary profession; men who were in the front rank of American novelists complained of neglect and lack of financial support. Yet, among the upper classes, education was not backward. There were no common schools, but excellent academies and colleges supplied their place. Little attention was paid to the sciences in the curriculum of these institutions, and technical education was absolutely undeveloped. The whole scheme of training was devised to make orators, who were to move the masses by the charm of the spoken word. The choice of a vocation was confined almost exclusively to the pulpit, the bar, and the forum, and on account of the great interest in politics the majority of the educated men preferred to expend their energies in political controversies.

The same conditions produced an equally noticeable effect on the material life of the community. There was little in the way of

manufacture or trade with other sections. The methods of transportation were extremely primitive, and the conservatism of the people created a serious opposition to the building of railways. Each planter had his own carriages, wagons, and carts, and a long trip to market was only a pleasant diversion, time being of slight value. As each plantation was an economic unit, very little was necessary in the way of trade. The commercial transactions were largely conducted by barter, and there was little necessity for ready money. Agriculture was the main pursuit, and its main staples—tobacco, cotton, and rice—were confined to this section. Although so much of the life of the community was devoted to agricultural pursuits, the operations of the farm were rarely conducted on business principles, or with any attention to the teachings of science. The planters could afford to take life easily. Their chief duties were to make long visits to relatives and friends, to ride, fish, and hunt, and, above all, to discuss the affairs of state.

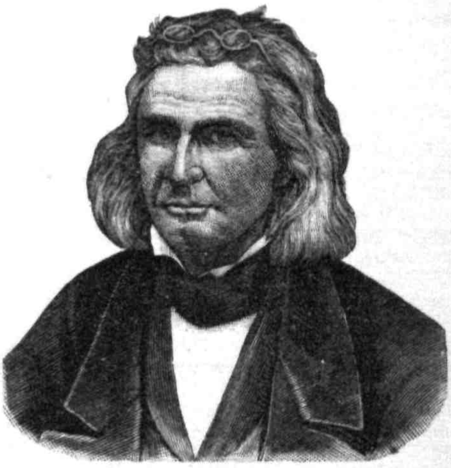


FIG. 128.—Edmund Ruffin.

EDMUND RUFFIN.

It was under such conditions as these that Edmund Ruffin lived. He recognized the difficulties inherent in his times, and was not discouraged by the conservatism against which he labored, being a man of independence and great firmness of purpose.

Edmund Ruffin was born January 5, 1794, on his father's plantation in Prince George County, Va. His father was a gentleman of fortune, a typical planter of the olden time. From his earliest youth Edmund was an intelligent reader of the literature of the day, although his reading was rather for amusement than for instruction. As was the custom, his father decided to give him the education due him as the son of a wealthy Virginia gentleman, and with this end in view sent him at the age of 16 to William and Mary College. The change from the quiet life on the plantation to the excitement at college was evidently not the best thing for the young planter, for, after an unprofitable connection with the institution, he finally left under unpleasant circumstances.

At this time the war of 1812 broke out, and he enlisted in a volunteer company, serving from August, 1812, to February, 1813. He left

the army probably on account of his father's death, which must have taken place at about this time, for in the year 1813 we find him placed in the possession of an extensive estate at Coggins Point, in Prince George County, and he states that, although not of legal age, the "easy indulgence of his guardian" gave him the control of this property.

We must sympathize with Mr. Ruffin in the difficulties under which he labored in his early efforts to make a success of agricultural operations on his estate. He had gained no practical knowledge of the field work of agriculture in his youth, and he had therefore to learn the most rudimentary principles. Yet the farm operations were so simple in his day that he soon mastered their details. In his reading he chose rather the agricultural writings of the time. These were mostly planned to satisfy other conditions, such as existed on the great estates of England, and much of their teaching was inapplicable to the conditions existing in Virginia. But the perusal of these works gave him an insight into the scientific methods used in other countries, which offered a sharp contrast to the slipshod methods in vogue in his own State. He saw that the latter were "wretched in execution and erroneous in system."

EFFORTS TO INCREASE THE FERTILITY OF THE SOIL.

In the same year in which he began his control of the estate there appeared the first book devoted to the discussion of Virginia agriculture. This work, written by Col. John Taylor, a prominent planter of Caroline County, was printed in Georgetown, D. C., in 1813, under the title, "Arator: being a series of Agricultural Essays, Practical and Political * * * by a Citizen of Virginia." It had previously been published as a series of articles in the "Spirit of Seventy-six," in 1809 or 1810. The work at once attained great popularity, and was issued in at least six editions. Colonel Taylor's views may be summarized briefly as follows: The secret of success in agriculture lies in the free use of putrescent vegetable matter as a manure. In the ordinary process of handling such materials as are used for this purpose, much of the valuable fertilizing material is lost, being of a gaseous nature and passing off into the atmosphere during the process of putrefaction. The manures should be, therefore, incorporated with the soil before the processes of decay are started, so that this valuable matter may be saved. Too much land is used for grazing. This land should be used rather for the cultivation of crops, and the crops fed to the cattle at once (the modern soiling system). The manure made by the cattle should be at once plowed under, together with the waste from the fodder. Clovers should be largely grown and plowed under to add fertility to the soil. Gypsum will increase the clover yield. Deep plowing should be the rule.

It was natural that Mr. Ruffin should at once become an admirer

of Taylor's system of husbandry. He recognized the fact that the exhaustion of the fertility of the soil was the great difficulty with which he had to contend, and welcomed any system calculated to improve it in this respect; but he at once met with difficulties in the attempt to apply the principles to his own practice. His land was not suited to clover, and he found it impossible to get a crop. The soil was shallow, and the ridge system advocated by Taylor subjected the sidehills to injurious loss from washing. Nor did the land respond to the use of vegetable manures to the extent expected. After six years spent in the attempt to apply these principles, meeting with nothing but failure, he was compelled to confess that "no part of my poor land was more productive than when my labors commenced, and on much of it a tenfold increase had been made of the previously large space of galled and gullied hillside."

At this time Mr. Ruffin had an opportunity of examining a copy of Sir Humphrey Davy's Lectures on Agricultural Chemistry, and naturally sought for a reason for the lack of effect of "putrescent manures" in his particular region. He found the following passages:

> If on washing a sterile soil it is found to contain the salts of iron or any acid matter, it may be ameliorated by the application of quicklime.
>
> A soil of good apparent texture from Lincolnshire was put into my hands by Sir Joseph Banks as remarkable for sterility. On examining it I found that it contained sulphate of iron, and I offered the obvious remedy of top-dressing with lime, which converts the sulphate into a manure. [Ed. 2, London, 1814, p. 203.]

Mr. Ruffin at once saw a parallel between the soil mentioned by Davy and that of his own farm. He tested the soil for the salts of iron, but could not detect a trace of the copperas which he expected to find. In studying over the matter he was attracted by the expression in the first sentence, "if it is found to contain the salts of iron or any acid matter." While he recognized the intention of Davy to refer to the mineral acids only, which he knew by direct testing to be absent from the soil of his farm, he conceived the idea that the sterility might be due to the presence of organic acids in the soil, which acted as a "poison" to the crops. This view was partially confirmed by the character of the vegetation on the worn-out land in question, which consisted largely of sheep sorrel and similar plants known to contain free vegetable acid. He noticed also that those portions of his land did not respond to a test for lime. His more fertile soils, however, were "shelly" in character, and there was no trace of the acid plants growing on them. He could not, however, obtain any evidence of a direct nature that the vegetable acids were present in the sterile soils, nor in his extensive reading could he find a single mention of the occurrence of these substances in any soil. The existence of the vegetable or humus acids was not proved until a much later date.

From these meager indications Mr. Ruffin drew his theory of the action of lime on the soil, and at once proceeded to put his ideas into

practice. He found on his own farm extensive beds of shell marl and decided to use this material, which was cheap and easily accessible in unlimited quantities. The existence of these beds had been well recognized, and a large amount had been burnt into lime for structural purposes.

Lime in the form of quicklime, limestone, marl, etc., had been used on the continent of Europe for many centuries. There are several instances of earlier use of marl in America, and in the State of Pennsylvania the use of quicklime had become almost universal. In none of these instances, however, had lime or marl been used with a definite object in view, or with any other purpose than the general improvement of the land; nor had any experiments been made except in the application of the lime and a guess or inaccurate statement of the increase in yield.

EXPERIMENTS IN THE USE OF MARL.

Mr. Ruffin began his experiments with marl in February, 1818, excavating a large amount of the mineral and applying it to a portion of a tract of land which had just been cleared of forest growth. The application was made at the rate of 150 to 200 bushels to the acre. From the land thus treated he obtained an increase of 40 per cent over the crop on similar land untreated. Encouraged by this result, he planned more extensive experiments for future years. Without entering into the details of these trials, the result may be stated as overwhelmingly in favor of the use of marl; in some instances the crop from the marled fields was more than twice as great as from the same fields before marling.

It is not to be understood that Mr. Ruffin advocated the use of marl alone with the expectation of thus building up the fertility of the soil. His object was rather to bring the soil into such condition as would make it respond to an application of organic manures which had been previously found to be of little value when used on the land in its ordinary condition. He retained as much of the teachings of Taylor as placed great stress on the value of vegetable manures, and used every effort to add as much organic matter as possible to the soil on his farm.

The experiments were continued for a long series of years, accurate records being kept of the history of each plat of ground, frequent comparisons being made between the measured yields of marled and unmarled fields. Marl was tried with and without manure, and manure was tried with and without marl. The greater the number of experiments and the more numerous the results obtained the greater proof was given that the use of marl was of great advantage. The careful manner in which the experiments were carried on shows him to rank as one of the most intelligent experimenters of his time. The investigations were not confined to mere field trials. The soil of

his plantation was analyzed, the marls used were analyzed, and the results were carefully studied. He searched the literature of every age for mention of the occurrence of marl and the history of its application to the purposes of agriculture. He was familiar with foreign publications on the subject, not only reading thoroughly, but studying, comparing, and making extracts as he found matter worthy of future reexamination. He collected information as to the character and extent of deposits of calcareous substances in his native State, and devoted much time to a study of the best and most economical methods for its exploitation. He figured carefully the cost of applying the marl, and estimated the financial returns from its use. Every line of inquiry which could possibly add to his general stock of information was carefully followed to the very end.

HOW MARL INCREASES FERTILITY OF SOIL.

His reasons for the use of marl, gained from his experience and study, were two in number. He believed that the addition of marl corrected the natural acidity of the soil, and that it assisted in the preservation of organic manures from loss of the gaseous products of decomposition while hastening the decomposition itself. He foreshadowed to a great degree the discoveries of later years with reference to the action of soil bacteria; for, as is now well known, certain of the nitrifying organisms in the soil are capable of action only in neutral or alkaline soils, and thrive best in the presence of a small amount of alkali. The sterility of many of the soils in eastern Virginia was probably due to conditions present which are unfavorable to the growth of the nitrifying organisms, owing to the presence of organic acids in the soil. The richest soils in the world contain large quantities of organic matter, and probably some proportion of the humic (organic) acids; but they also contain sufficient lime to unite with these acids, and thus neutralize them to a large extent.

The marls first used by Mr. Ruffin were valuable only from their content of lime, no phosphoric acid or potash being present; but later, and especially after his removal to his estate at Marlbourne, in Hanover County, he used greensand, called by him "gypseous earth," which contained certain amounts of potash, and probably also contained phosphoric acid. He does not seem to have recognized the value of these ingredients, basing his opinion of the value of these marls on the carbonate of lime contained. We can hardly overlook this mistake, although it was excusable at a time when the knowledge of agricultural chemistry was extremely limited.

The first published article from Mr. Ruffin's pen was "An essay on calcareous manures," in the American Farmer, Vol. III, p. 313 (the number for December 28, 1821). This essay had been prepared and read before a meeting of the Prince George Agricultural Society, of which Ruffin was a member. The essay was afterwards published

in book form, reaching its fifth edition in 1852. From a short article of 7 pages it expanded to a book of 493 pages. It is probably the most thorough piece of work on a special agricultural subject ever published in English. The treatment of the subject is historical, scientific, and practical, exhausting every source of information available. From the first publication, this essay attracted great attention, and is even now the best authority on certain phases of the subject. As a result of this and other publications by the same author, a large proportion of the farm owners in the tide-water district of Virginia were led to use marl, and, what is more important, were aroused by his example to a sense of the importance of personal attention to the needs of their estates and to details of management. At the time of the publication of the fifth edition of the essay, the effect of his teachings was so plainly evident that attention was called to the matter by the governor of the State in his annual message to the legislature in the following words:

The increased value of the lands lying in the tide-water district, as exhibited by the returns of the recent assessment, vindicates the science [of agriculture], and appeals strongly to you for aid and encouragement in its behalf. In 1819 the lands in this district were valued in the aggregate at the sum of $71,496,997, and in 1838 at $60,704,053.20, exhibiting a decrease in value during the nineteen years that intervened to the enormous amount of $10,792,943.80. And yet these same lands were recently assessed at the sum of $77,964,574.52, showing an increase in their value during the last twelve years of $17,260,521.32.

This remarkable and gratifying change in the value of these lands can not be attributed to any extent to benefits resulting from the works of internal improvement, for thus far these improvements have been chiefly confined to other sections of the State. And in vain do we look for a solution of this problem, unless we remember that for several years past the enterprising citizens of this section of the State have been devoting themselves to the subject of agricultural improvement; and by the proper application of compost, marl, and other manures, and the use of other means which a knowledge of this branch of education has placed at their command, they have redeemed, and made productive and valuable, lands heretofore worn out by an improper mode of cultivation, and consequently abandoned by the farmer as worthless and unfit for agricultural purposes.

FARMERS' REGISTER.

Early in the year 1833 Mr. Ruffin issued, as editor and proprietor, the first number of the Farmers' Register, a monthly agricultural magazine of 64 pages of reading matter. In the editorial column of the first number, after calling attention to the low state of agriculture in Virginia, and discussing the reasons for the same, he announces that the journal is started to serve as a medium of exchange between the farmers of the State, and that this shall be the chief feature. The Farmers' Register was published for ten years, the second volume being printed on the estate of Mr. Ruffin at Marlbourne (Shellbanks); the subscription price was $5. The influence of this journal on the agriculture of the State was very great, the tone was high, and the articles were carefully written, or selected from the better class of

agricultural publications. Nearly half of the reading matter came from Mr. Ruffin's pen, and the subjects on which he expressed himself were extremely diverse in character.

Although much of the matter published in the Farmers' Register had a direct bearing on the marl question, nearly every issue containing something on the editor's favorite hobby, yet it was not by any means the only subject discussed. Every conceivable question in which the farmers of the State might be interested, or which could affect their welfare in the least, was carefully treated. Much attention was given to the development of roads and railways in the State. Much was written on the slavery question. Agricultural education was discussed at length. But the operations of a practical character, the field work of the farmer, received the greatest attention.

The difficulties attending the publication of such a paper at this period were at best discouraging. Mr. Ruffin complains with reason of the delay in the delivery of his paper, which in one instance required fourteen days to reach a subscriber at a distance of 180 miles. The first volume was printed on poor paper, although it is now in far better condition than can be hoped for a copy of the ordinary agricultural paper of to-day at the end of a similar period. He suffered from the delinquent subscriber, and from the subscriber who thought that the price should be reduced. He attempted, as has already been stated, to print the paper on his estate in Hanover County, but probably found the task too great, as the third and subsequent volumes were printed at Petersburg.

As appendixes to the Farmers' Register were printed the seventh edition of Arator, in 1840, the Westover Manuscripts, in 1841–42, and the third edition of the Essay on Calcareous Manures, in 1842. This was done to insure the wide distribution of these works, and incidentally to save cost of transmission.

PUBLIC SERVICES OF MR. RUFFIN.

At the meeting of the legislature of the State in 1841, a State board of agriculture was organized and Mr. Ruffin was elected a member; in December of that year he was selected secretary and held that position for a year. In 1842, the State of South Carolina having made an appropriation for an agricultural surveyor, Mr. Ruffin accepted the position and published, in the following year, his first report, being mostly a statement of the occurrence of beds of marl in the State and a plea for the drainage and reclamation of the swamp lands. On his return to Virginia he was instrumental in founding the Virginia State Agricultural Society and was elected the first president. He advocated, with others, the establishment of a State commissioner of agriculture, with a good salary, and the right to employ certain scientific assistants, but the plan did not meet with the approval of the legislature. At various periods during his life he was connected with

local agricultural societies, and by his earnestness and enthusiasm aroused much interest in cooperative work.

Mr. Ruffin was an enthusiastic advocate of higher education, suggesting the establishment of an agricultural college supported by the State. In the main, the details of his plan were such as are in operation in the agricultural colleges of the present, except that the students might pay all their expenses by work in the experimental fields connected with the college. The experience of past years has shown this to be impossible. An essay on the subject of agricultural education, published at Richmond in 1853, won a prize offered by the State Agricultural Society.

As was usual with the prominent men of Virginia, Mr. Ruffin took great interest in the political affairs of his native State. In 1824 he was elected to the senate of Virginia, and served three years. In 1841 he published Observations on the Abuses of the Banking System, and in the following year at least six numbers of a periodical publication under the name Bank Reformer. These works were called forth by the financial agitation of the time.

In 1855 a collection of the more important agricultural writings of Mr. Ruffin, previously published in various periodicals, were gathered together in Essays and Notes on Agriculture. This included an essay on drainage, a prize essay on the Southern cowpea, a discussion of remedies for malaria, and articles on the culture and uses of clover, method of harvesting wheat, the moth weevil, prairies, deserts, peat bogs, usefulness of snakes. This list illustrates the versatility of the man, but can give no idea of the real value of each article or the concise and easy style of the author.

The good resulting from the agricultural teachings of this man would to-day be more evident had not the war left the State of Virginia in a very depressed condition. The use of marl, once so common, has been displaced to a large extent by commercial fertilizers. The cheap slave labor made it possible to obtain marl at slight cost; it does not now pay to carry it to any distance. Most of the men whose energies were spurred to new effort by his ready pen have passed away; but among the intelligent farmers of the State he is still remembered, and his teachings are often followed by those who have never heard his name nor read what he has written.

Edmund Ruffin conducted his experiments with such attention to details and with such a truly scientific method of preparation and planning that we may look on his work as some of the best done in the country. He certainly was ahead of the investigators of the day. He proved by experimentation not only that the practice of the farmer is often ahead of the proof of the theorist, but that the work of the theorist is often of great practical benefit to the farmer.

WORK OF THE DEPARTMENT OF AGRICULTURE AS ILLUSTRATED AT THE ATLANTA EXPOSITION.

By Robert E. Wait, B. A.,

Private Secretary to the Assistant Secretary of Agriculture.

It is but adding to the credit of the whole exhibition to record here the opinion expressed by many impartial visitors that the United States Government exhibit was the crowning feature of the Cotton States and International Exposition held at Atlanta, Ga., September 18 to December 31, 1895. It was a recognition of the magnitude and importance of this exposition that the Government, in pursuance of an act of Congress appropriating $200,000 for the purpose, should go to the pains of sending to Atlanta a collection of exhibits so complete and valuable as to equal in quality, if not in quantity, the Government display at the World's Columbian Exposition at Chicago. In the Government building, a structure of graceful proportions and in harmony with the prevailing architectural features of the Exposition, containing some 58,000 square feet of floor space, erected at a cost, in round numbers, of $50,000, and occupying a commanding site in a high quarter of the Exposition grounds, were gathered together from the eight Executive Departments of the National Government, the Smithsonian Institution and National Museum, and the United States Fish Commission, such articles and materials as, in the language of the act, "illustrate the function and administrative faculty of the Government." These distinct and varied exhibits, being under the control of a single board of management, were so arranged and displayed as to form one attractive and harmonious whole, affording a sufficiently detailed and yet comprehensive ocular demonstration of what our Government has done and is doing for the people of the United States.

One of the most interesting and instructive displays in the Government building was that of the United States Department of Agriculture, the main portion of which occupied 8,000 square feet of floor space near the center of the building. The eye of the visitor entering at the main door fell first, probably, upon a large facsimile of the seal of the Department, illuminated in colors, held by an American eagle, hanging over the main aisle. The Department seal, in letters large enough to be easily read, proclaimed the fact that "Agriculture is the foundation of manufacture and commerce," a statement the truth of which is at once apparent in the exhibits. Proceeding

on a realization of its importance to the people, the Department's exhibit was collected and arranged with a special view to giving the visitor a clear idea of what the Department of Agriculture is, what it has done, and what it is doing for the agricultural interests of the

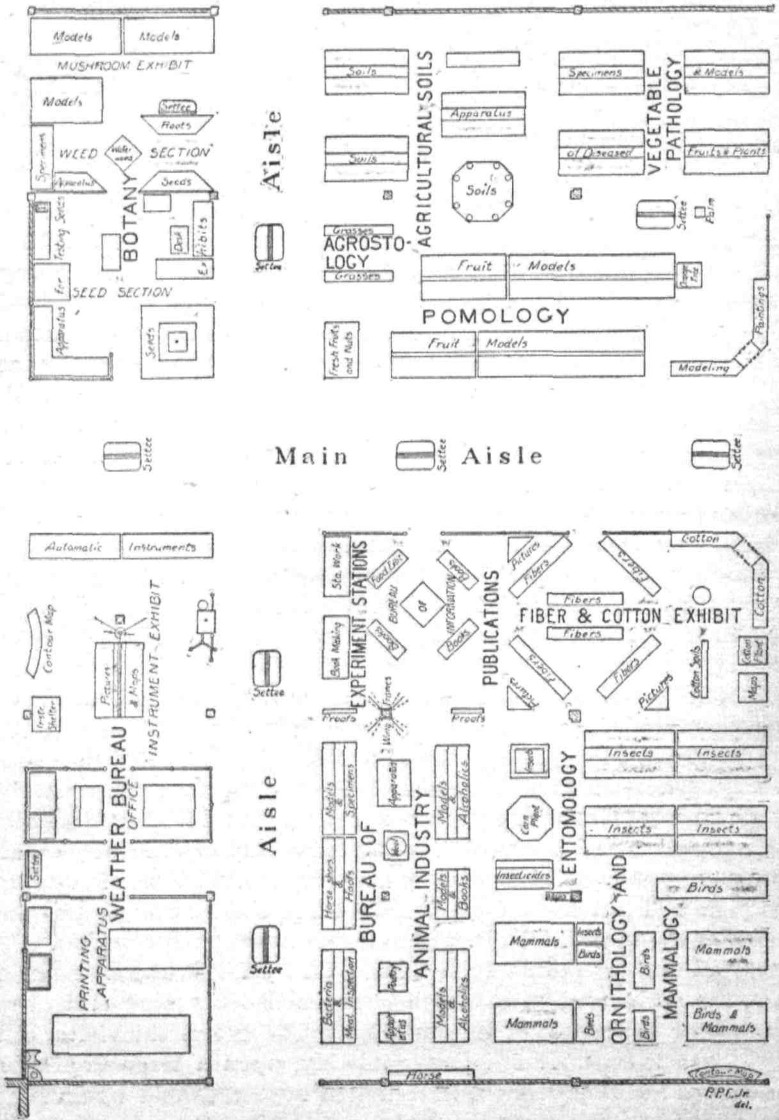
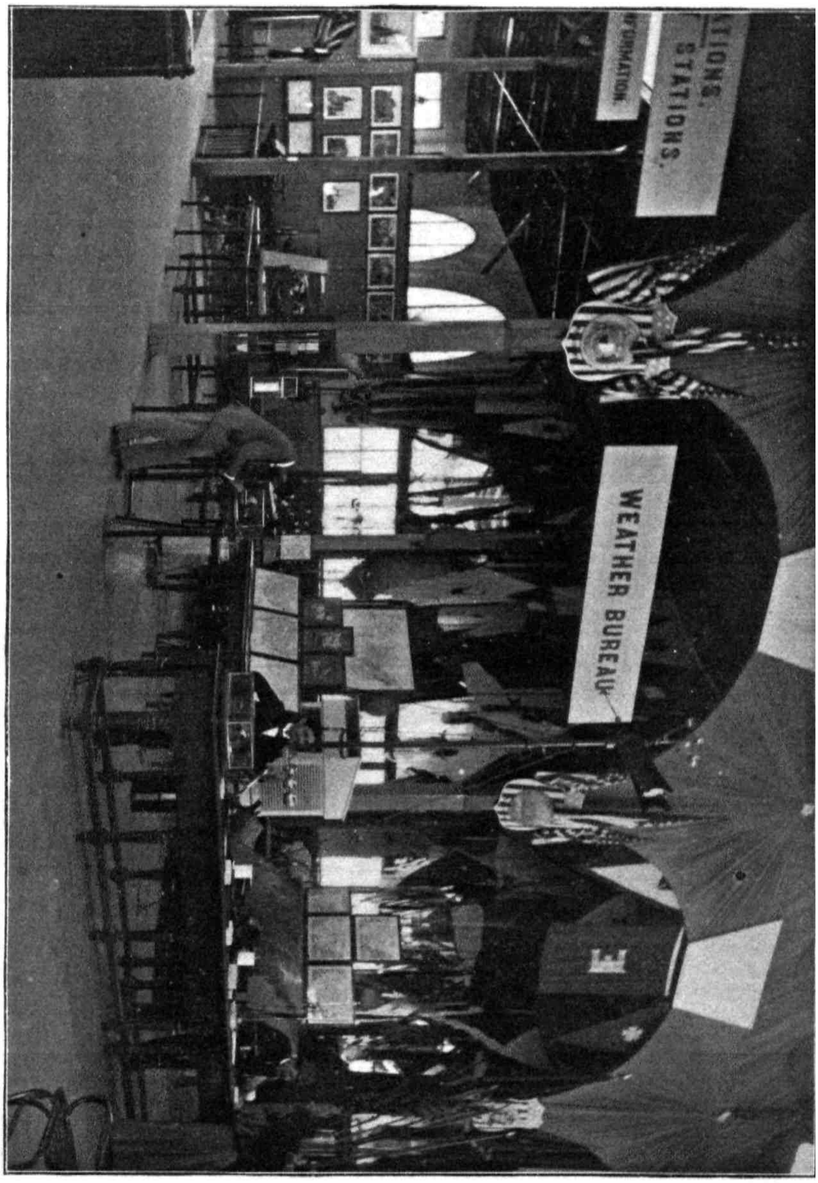


FIG. 129.—Diagram of exhibit of U. S. Department of Agriculture at Atlanta Exposition.

country, as well as some hint of the possibilities of the future. It developed the fact that in the performance of the general purposes of the Department, as stated in the organic act creating it, the scope and character of its work have been from time to time enlarged until



VIEW OF EXHIBIT OF U. S. WEATHER BUREAU AT ATLANTA EXPOSITION.

they now embrace many subjects not thought of when the Department was created, but which scientific research has since shown to be vitally connected with agriculture. It may, therefore, be possible in this place, without attempting a full report or a complete list of its exhibits, to impart some knowledge of the nature and scope of the purpose and work of the Department of Agriculture by glancing at the evidences of some of its actual achievements and its facilities for further usefulness, as they were displayed at the Atlanta Exposition.

The complete exhibition by the Department comprised the exhibits (see diagram, fig. 129) of two bureaus and nine divisions in the Government building, a good-roads exhibit on the grounds, and an exhibit of the Division of Forestry in the Minerals and Forestry building, all collected and arranged by the chiefs or representatives of the respective bureaus and divisions, under the personal supervision of Dr. Charles W. Dabney, jr., Assistant Secretary of Agriculture, who was appointed to represent the Department of Agriculture on the Board of Management of the United States Government exhibit, and later was designated chairman of the Board by President Cleveland.

EXHIBIT OF THE WEATHER BUREAU.

Man is so dependent upon the weather and so variously affected by it that it is at all times a subject of vital interest to him. Wherever, therefore, he has gathered in communities sufficiently large, the Government has provided agencies to inform him accurately not only of the weather conditions immediately surrounding him, but also of those covering the whole country, in order that the coming of a devastating wind, a rain or snow storm, or a cold or hot wave may be announced in time to enable him to prepare for it. All this the Government accomplishes by means of its Weather Bureau, which, owing to the popular interest in the subject and the large number of stations and substations and of voluntary observers in all parts of the country, is probably the best-known agency of the Department of Agriculture. It is not surprising, then, that its exhibit proved a most attractive one.

It embraced charts presenting the important features of the climate of the United States; photographs of cloud effects and lightning flashes; standard forms of instruments used by the Weather Bureau, such as anemometers to measure the velocity of the wind, wind vanes, rain gauges, temperature instruments, barometers, and instruments for measuring the duration of sunshine; methods of forecasting weather, and the printing of a daily weather map. These were all explained to visitors by the officials in charge. (See Pl. VIII.)

The observant visitor, who had at his home noticed a difference between the temperature reported officially by the Weather Bureau on a hot summer day and that indicated by the thermometer at the corner drug store, found the explanation in the "thermometer shelter" exhibited. This consists of a wooden box with louvered

or slatted sides and double roof, and is employed by the Weather Bureau for the purpose of screening the instruments within from every influence except that of free air that can affect their temperature, such as rain, sunshine, or strongly reflected or radiated heat from any source.

A new and improved form of automatic rain gauge, called the "tipping bucket," illustrated the practical working of one of the devices used by the various Weather Bureau stations throughout the country to measure the rainfall. Another interesting exhibit was a new form of sunshine recorder, which operates on the principle of a differential air thermometer, and by suitable electrical connections produces a record which gives the number of hours and minutes of bright sunshine.

Every day, except Sunday, between the hours of 10 a. m. and 1 p. m., a printing press was in operation, turning off weather charts showing the weather conditions prevailing over the country at 8 o'clock in the morning and giving a forecast of the weather for Atlanta and its vicinity for the succeeding twenty-four hours. This was a practical illustration of the principal work of the Bureau, to which all its investigations lead.

The observations upon which the forecasts and warnings of the Weather Bureau are based are made at the same moment at all stations; that is, daily at 8 a. m. and 8 p. m., seventy-fifth meridian time. Reports are immediately telegraphed to the central office at Washington, D. C., over a special arrangement of telegraphic circuits set apart each day at these hours for this purpose. In order to show the methods of forecasting, the Weather Bureau exhibit was equipped with complete forecasting and map-printing sections. Copies of the telegraphic weather reports of the morning observations were received in the forenoon of each week day. The first step in their treatment consisted in the translation of the abbreviated cipher code employed in the telegrams, and the entry of the reports on the map at the point representing the location of the station sending the report. Two sets of lines were then drawn upon the map. The isotherms, or temperature lines, for each 10 degrees of temperature, were in red, and showed in a graphic way the relation between the temperatures of the several portions of the country. The isobars, or atmospheric-pressure lines, for each tenth of an inch of barometric height, were in blue, and enabled one to perceive at a glance the manner in which the air pressure is distributed. A map so prepared constituted the original manuscript weather map for that observation. From it, with reference to similar maps of preceding days, the forecaster prepared the predictions and warnings for his section of the country.

At the central office in Washington, the forecast official makes his forecast for the whole country. In forecasting, the air pressure is probably the most important feature to be considered in arriving at

an opinion as to what the weather is to be. The force and direction of the wind depend upon this. Under typical conditions, such as exist generally when pronounced wind and rain storms prevail, the air pressure will be low in one portion of the atmosphere and high in another. These regions constitute the so-called "lows," or cyclones, and "highs," or anticyclones, of the meteorologist. Clear and cool weather with light winds is more apt to accompany the "high," while cloudiness and rain or warmer, windy weather occurs with the "low." "Lows" and "highs" never remain stationary for any length of time, but move in the same general way in an easterly direction. A "low" that appears in the northwest will never cross the Rocky Mountains and move over the Pacific Ocean, but will go eastward generally across the Northern States and lake region, passing out along the St. Lawrence Valley. "Lows" that sometimes appear in Texas and the eastern Gulf region follow a more northeasterly course, both going out over the ocean near the New England coast. All this was demonstrated in the preparation and printing of the map at the exhibit every day. These maps were distributed to the visitors, and were carried away by many as souvenirs.

EXHIBIT OF BUREAU OF ANIMAL INDUSTRY.

Probably the next best-known work of the Department of Agriculture is that carried on by the Bureau of Animal Industry, which is an administrative as well as a scientific agency of the Department, employing nearly 700 persons outside of its central office at Washington. Horses, cows, hogs, and chickens are so closely connected with agriculture, and are, like man himself, so liable to disease, that exhibits showing the effect upon the body of the various diseases of domestic animals always prove interesting. But the Bureau of Animal Industry goes even further than the treatment of diseases in animals, and endeavors to prevent disease in human beings by a careful inspection of exported and imported meats and meat-producing domestic animals intended for man's consumption. This work was illustrated by means of enlarged bromide prints and photographs and alcoholic specimens relating to the various contagious and infectious diseases, and wax models, which not only served to show the changes in conformation resulting from disease processes, but also the color transitions from the normal to the diseased state.

That terrible disease, glanders, was most strikingly illustrated by means of the stuffed skin of a horse, which, during life, had the disease, and by diseased portions taken from other affected animals. Glanders was shown to be primarily a disease of the horse, but communicable to other animals as well as to man himself. To show its terrible effect upon man, there were exhibited casts of the face and of a forearm of a man suffering from it. This disease, when it enters the human system, sets up a violent inflammatory process, which ends

fatally in a few days. It has also been found that consumption can be communicated to man by the eating of diseased meat, or meat taken from cattle suffering from pulmonary tuberculosis, or consumption. The exhibit, therefore, contained a large collection of specimens and models, showing the ravages which this disease makes in the lungs and other organs of cattle. At one time contagious pleuro-pneumonia was quite prevalent in cattle in central and eastern portions of the United States, but owing to the work of the Bureau of Animal Industry in the rigid enforcement of the Federal law concerning it, this dreadful disease has been entirely eradicated. Under this law affected animals were appraised and destroyed, contaminated premises were disinfected, and where this was impossible the buildings were destroyed, and cattle which had been exposed to the contagion were isolated and closely watched. It took just five years for the Bureau to effect this, and in 1892 the late J. M. Rusk, then Secretary of Agriculture, issued a proclamation declaring the United States free from pleuro-pneumonia. Specimens were exhibited showing how this disease affected cattle.

Other diseases were graphically illustrated, among them Texas fever, at present one of the most important cattle diseases in this country, existing mainly in the Southern States. A map of the United States was exhibited, which showed the area permanently affected by this fever. Since it has been found that the disease can be communicated by cattle ticks, it has also been shown that the disease can be prevented by keeping cattle free from ticks. A number of insecticides were shown, by the use of which the small farmer can keep the ticks off his cattle. Another interesting exhibit of the Bureau consisted of specimens and models illustrating infectious swine diseases which are indigenous to this country, the chief of these being hog cholera and swine plague. These two diseases were represented by alcoholic specimens of the intestines of hogs which had succumbed to hog cholera, and by parts of the lungs showing the changes in structure in that organ brought about by the disease process known as swine plague. It was explained that some success had been attained in finding a combination of drugs which will act as a cure for this disease, and the Bureau now sends out to persons making proper application samples of the remedies used and the directions for making them. The diseases affecting poultry were also illustrated.

Some idea of the general inspection work of the Bureau was given by a bromide print of the inspection room at Chicago, showing 50 or more persons engaged in examining samples of meat from hogs which had been slaughtered for export trade. It is only on a certificate signed by the Secretary of Agriculture, stating that the inspected meat is free from trichinæ and other parasites, that our pork products are admitted to the markets of certain foreign countries. The rules regulating the importation of live stock into the United States are just as

rigidly enforced, and it is hardly likely that any of the European diseases can ever gain a foothold with us here. The work of this Bureau was also illustrated by the exhibition of photographs of its inspectors at work, and the various tags and implements used in inspection work. The dairy industry was represented by a large number of photographs of milch cows famous as milk and butter producers, and there were also in this collection, of much interest to horsemen, exhibits designed to illustrate the various diseases and malformations of the horse's foot, as well as to show the proper patterns of shoes to use in such cases.

EXHIBIT OF THE DIVISION OF ORNITHOLOGY AND MAMMALOGY.

The exposition being held in a cotton State, the Division of Ornithology and Mammalogy, which is charged with two lines of work—a biological survey of the United States and investigations concerning the economic status of birds and mammals that are injurious or beneficial to agriculture—took special pains to make an exhibit of characteristic birds and mammals of the life zone of the country embracing the cotton States. It is well known that animals and plants are not distributed uniformly over the earth, but are restricted to certain more or less well-defined areas, outside of which they do not occur; and one of the most interesting of these defined areas, both on account of its extent and its importance agriculturally, is that including the greater part of the South Atlantic and Gulf States. This is the zone of the cotton plant, sugar cane, rice, pecan, and peanut, of the pear and grape, and, in more southern parts, of the citrus fruits. A part of the exhibit, made to represent a scene on the border of a Southern swamp, contained two or three species of herons, a roseate spoonbill, a purple gallinule, and a king rail. A night heron and wood duck were perched on a branch overhead, while a prothonotary warbler, a cardinal, and a painted bunting could be seen in the undergrowth. In a tree on the bank were several raccoons, the whole making a natural assemblage of species peculiar to the locality, with appropriate surroundings. In striking contrast to this was a case containing a tract of desert, with a group of kangaroo rats and cactus wrens, illustrating the difference between the fauna of the humid parts of the Gulf States and that of the arid western part. There were also colored relief models, showing the extent and boundaries of all the life zones of the United States, and maps giving in detail the distribution of a number of species of mammals and birds.

Conspicuous among the exhibit devoted to animals of economic importance was a coyote in the act of seizing a sheep. In the West the coyote is one of the worst enemies of the sheep owner. There was also a lynx eating a grouse, and groups of weasels, skunks, and minks capturing their prey. Weasels and skunks, because of the visits they sometimes pay poultry yards, are commonly looked upon as enemies of the farmer, but, as a matter of fact, they are among his best friends, their ordinary everyday food consisting mainly of mice, gophers, and

insects. The same was shown to be true of hawks and owls, which though commonly persecuted as enemies, have been shown by this division to rank among the most beneficial of birds, more than 90 per cent of their food consisting of mice, insects, and other vermin. Special prominence was given to the injurious animals of the Mississippi Valley. A scene familiar to many visitors was a group of rice-birds gorging themselves in the rice field. Close by, the same bird was shown in its summer home in the North, where it is nothing more or less than the well-known bobolink, a harmless inhabitant of the meadows.

In its endeavor to find out what birds and mammals are beneficial or injurious to agriculture, this division has found that many which were formerly considered enemies of the farmer are really his best friends in disguise, and the chief aim of its exhibit was to point out to the agriculturist his enemies and his friends among the birds and animals that frequent the farm.

EXHIBIT OF THE DIVISION OF AGRICULTURAL SOILS.

The exhibit of the Division of Agricultural Soils was neatly arranged in a pagoda and three large cases. The roof of the pagoda was supported by eight glass columns, each filled with a separate grade of sand, silt, and clay, which make up the texture or framework of most agricultural soils. Inside of the pagoda were a number of 3-gallon glass bottles containing water, to illustrate the amount of water in a cubic foot of some of the principal types of soil adapted to different classes of crops. There was also a large cube of soil with a wax model of a tobacco plant and a description of the principal physical properties of the soil. In other cases were exhibited eight different grades of sand, silt, and clay in the exact proportions in which they are found in soils adapted to certain of the principal crops. All this was intended to illustrate the marked difference in the texture and physical properties of soils adapted to different crops and to thus enable the farmer or planter to suit his planting to the soil. For instance, the exhibit showed that the truck soils of the Atlantic Coast are composed largely of sand and contain a very small percentage of clay, while the strong grass lands of the Atlantic Seaboard contain a very large percentage of clay and but little or none of the coarser grades of sand. The effect of this was shown in the amount of water maintained by these two types of soil. The truck soil, owing to its loose, light texture, allows water to percolate through it rapidly, and maintains but a small amount for the use of crops while the strong clay soil, by offering a far greater resistance to the descent of water, maintains a much larger amount for the use of crops. These more moist conditions are found to be favorable to such plants as grass and wheat, which require a long, uniform growing season in which to gather from the soil and atmosphere a large

amount of food. The drier conditions in the truck soil are not favorable to the production of so large a crop, but the crop matures early in the season, when there is no competition from the crops on the heavier soils.

Different types of tobacco soil were shown, for the purpose of illustrating the very important influence of the texture and physical properties of soil on the development and type of tobacco. The bright tobacco soils of the South are found to have a texture very similar to the truck soils of the Atlantic Coast, and produce a small plant with a thin-textured leaf which cures to a fine golden color, if properly treated. The heavy shipping tobaccos are grown upon much heavier soils, which contain a considerably larger percentage of clay, and are much more retentive of moisture than the bright tobacco lands.

The texture of the sea-island cotton soil exhibited was quite similar to that of the truck soils already mentioned. This soil is now used very generally for the trucking interest. The best type of upland cotton soil was shown to be stronger than the sea-island soil, containing from 20 to 30 per cent of clay. A soil containing less clay than this, or maintaining less moisture than such soil normally does, is found to produce small plants, which put on a quantity of fruit in proportion to their size, and give a relatively small yield per acre, while a soil containing considerably more clay generally produces large plants and a luxurious growth of the vegetable part of plants, but with little tendency to the production of fruit.

The presence of all these samples of soils naturally stimulated a desire to see the methods used by the division for collecting them and separating them into their component parts. The beaker method for separating the different-sized grains of sand, silt, and clay, commonly used in the Division of Soils, was shown to consist in allowing them to slowly subside in water, and then pouring off the liquid when grains of a certain size have settled to the bottom of the beaker. The method of determining the amount of moisture in the soil was also illustrated.

EXHIBIT OF THE DIVISION OF BOTANY.

It is of the utmost importance to the farmer to know that the seed he plants will grow and that he will reap that which he supposes he is sowing. This the Department of Agriculture has found it possible for him to determine beforehand by a simple seed test. The principal part of the exhibit of the Division of Botany, therefore, represented the working room of a seed laboratory, where seeds were tested to ascertain their purity and germinating capacity.

Commercial seeds, together with their impurities, were weighed in a pair of fine balances in order to find the percentage of good seed, and from the good seed duplicate lots were carefully counted out and placed in a germinating chamber whose temperature was controlled by means of a thermo-regulator. The records of purity and germination

were kept upon blanks prepared for that purpose. There was also exhibited a simple homemade apparatus for sprouting seeds, by which the ordinary agriculturist can arrive at an approximate idea of the value of the seed he proposes to sow. The necessity for seed-control work in America was emphasized by the exhibition of samples of different commercial seeds purchased in the open market, some of which were mere screenings, consisting almost entirely of dirt and weed seeds, offered to American seedsmen by foreign dealers for the purpose of adulterating pure seed. A class of inferior seed which is frequently found in American markets was illustrated by a sample purchased as yellow oat grass at $50 per 100 pounds, which consisted almost entirely of wood hair grass, worth about $10 per 100 pounds at wholesale. Of the 25.6 per cent pure seed, only 11.5 per cent germinated under the most favorable conditions, or a little less than 3 per cent of the entire sample, involving a loss in this particular instance of $84.72 out of the $100 invested in the seed, allowing 100 per cent germination for the wood hair grass.

In addition to a collection of the seeds of various forage and other economic plants, weed seeds, and seeds used in medicine, in the arts, and for food, was a fanning mill for cleaning small lots of seeds, accompanied by a case containing over 100 sieves of different kinds and sizes of mesh for separating impurities from good seed, since the problem of the best method of cleaning seeds is a very important one; and a seed-scratching machine from Denmark, so constructed as to break the seed coat enough to allow water to enter, without causing injury to the seed.

The importance of sowing seeds of large size was strikingly shown. An equal number of large and small seeds from the same sample were counted out and planted under the same conditions of heat, light, and moisture. The difference was very noticeable, the larger seed producing a heavier stand and larger plants.

Three cases filled with life-size models illustrating the common species of edible and poisonous mushrooms, colored to represent the natural specimens, indicated the results of the investigations of the Department along this line.

The remainder of the botanical exhibit was devoted to the illustration of the most troublesome weeds in such manner as to indicate the differences in the character of growth, manner of dispersion, and present geographical ranges of different species and, consequently, the different methods of eradication most applicable. Prickly lettuce and the Russian thistle, which have spread with greater rapidity than any other weeds in this country during the past quarter of a century, were illustrated with full-grown specimens dried in their natural form. These were accompanied by pressed specimens of seedlings so that they might be recognized upon their first appearance in new localities. Large maps showed the present distribution

of the Russian thistle, which has wrought such damage in the western portions of our country, and of other devastating weeds; and a collection of weeding tools showed the types of most of the implements used for hand weeding, the collection containing also a series of chemicals which have been found most effective in killing perennial roots.

EXHIBIT OF THE DIVISION OF POMOLOGY.

The fruit models exhibited by the Division of Pomology were so skillfully made and colored that the visitor found it impossible to distinguish them from the real fruit on exhibition. The exhibit was intended to familiarize growers and the general public with the wide range of fruit species and varieties grown in the United States, and to direct their attention to the importance of selecting proper varieties for planting in different sections. To accomplish this end, fruit models of more than 1,300 specimens, together with water-color paintings, photographs, fresh fruit, and living trees, were exhibited. These gave an opportunity for the comparison and estimation of the relative value of the different varieties for planting in different sections. The process of fruit modeling in the various stages of the work was also illustrated. Experiments in the preservation of fresh fruits in carbonic acid gas and vapor of alcohol were carried on during a portion of the time of the Exposition.

EXHIBIT OF THE DIVISION OF AGROSTOLOGY.

A beautiful collection of grasses admirably illustrated the work of the Division of Agrostology, which has lately been added to the Department, and whose duty it is to investigate the natural history, geographical distribution, and uses of grasses and forage plants, their adaptation to special soils and climates, and the introduction of promising native and foreign kinds.

But plants, like human beings, must combat obstacles to their growth, both from within and without. They are subject to wasting diseases and attacked by insect pests without number until they would soon be exterminated were it not for the work of the entomologist, who strives to protect them from injurious insects, and the plant pathologist, whose chief endeavor is to prevent and cure the diseases to which they are liable. This was illustrated at the Exposition by the exhibits of the divisions of Entomology and Vegetable Physiology and Pathology.

EXHIBIT OF THE DIVISION OF ENTOMOLOGY.

The entomological exhibit covered the principal insect enemies of the leading staples, and comprised, exclusive of cotton insects, upward of 600 injurious species. These were grouped according to plants and animals affected, and related to some 30 orchard, field, and garden crops, with parasites of domestic animals and household pests. There

was also a special exhibit of the more important scale insects affecting fruit trees, and eight large cases representing injuries by insects to forest trees. With each of the insects illustrated, an effort was made to furnish a complete object lesson of its life history, including examples of the injury done by it and an exhibition of its insect enemies and parasites, together with brief directions for remedial treatment and references to sources of fuller information. Insect enemies of cotton received special attention. This part of the exhibit included upward of 300 insects which occur on cotton and affect it either injuriously or beneficially. Of chief importance were two well-known cotton insects, the cotton worm and the bollworm. These, with other species, including the cotton-boll weevil, which has assumed special importance in the last year or two, were grouped together about an enlarged wax model of the cotton plant. In connection with them were wax models illustrating characteristic injury due to the bollworm and to the cotton worm. The bollworm exhibits included a collection of blown larvæ illustrating different stages, and a series of moths representing males and females; samples of injured bolls, showing different forms of damage; wax models illustrating injury to blooms, squares, bolls, and leaves; colored figures illustrating the insect in different stages, and its injury; and a wax model of a spray of cotton illustrating different forms of injury already enumerated. There was also a special exhibit of the chief insect enemies of citrus plants, more particularly of those of the orange and lemon.

The recent occurrence of the San Jose scale in the East, with the serious possibilities attending it, called for proper recognition and a special exhibit to meet the demand for information in this direction. Supplementing the more important exhibits were models in wax of the host plants and a model of the cotton plant. Indian corn was also the subject of a special model. There was also an interesting collection of silk insects, in response to the general curiosity which has been aroused in these insects, which are widely distributed in this country.

The work of the Division of Entomology would be incomplete if it simply pointed out the enemies to the plant, without furnishing some remedy. Great interest, therefore, attached to its insecticide exhibit, which included full directions for the preparation and application of each insecticide. The range or geographical distribution of important insects was graphically shown by means of charts and maps.

EXHIBIT OF DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

In the exhibit of the Division of Vegetable Physiology and Pathology four plant diseases were selected, the object being to show the steps taken in investigating the various problems connected with the work of the division. For instance, the malady known as "die-back" of the orange was shown to be due to the presence of certain nitrogenous compounds in the soil, and its peculiar characteristics were

illustrated by means of colored plates, drawings, and photographs. Specimens of the disease were also exhibited, so that anyone interested could follow the various stages from beginning to end. Following these were shown the various apparatus used in investigating the disease. Photographs of the division laboratory and its accessories were included in this part of the exhibit. The effects of different amounts of water on plants were shown, together with those of different nutritive matters.

The most important class of diseases treated was that produced by bacteria, illustrated by showing the results of investigations in pear blight, a disease which has annually caused a widespread damage to the pear crop for many years past. It was demonstrated that through the efforts of the division the cause of this disease has been determined and means of checking its ravages have been discovered. The pear-blight exhibit showed the general apparatus used in studying bacterial diseases, such apparatus comprising the microscope, the dishes, etc., for making artificial cultivations, gelatin tubes, broths, etc., containing the food supplies for the minute germs. Following this were actual cultures of the pear-blight microbe grown in artificial media. The effects of blight on trees were shown by photographs, colored illustrations, etc. Then the visitor was shown the method of combating the disease.

Another type of disease shown in the exhibit was that produced by fungi, a type of which is the so-called watermelon wilt, which is only too well known in the South. This disease was shown to have been produced by the minute fungus which attacks the stem of the plant and so affects it that it is unable to obtain water. As a result, the vines first wilt and then soon dry up and die. Methods for investigating and treating this disease were also shown.

In addition to all this the exhibit presented the different fungicides which have been found by long experience to be the most efficacious in the destruction of the fungus and fungous spores which come in contact with cultivated plants, and to effect such destruction without injuring the plants themselves. The various ingredients of these fungicides were also exhibited.

The wax model again came into play to illustrate a hundred or more diseases of leaves, branches, and fruit. In the case of citrus fruits, wax models of diseased and of healthy plants were shown, together with colored maps, illustrating the distribution of the various diseases in Florida. In the cotton exhibit of this division a number of the principal diseases were illustrated by means of colored paintings, which showed different stages of the diseases known as anthracnose, root rot, blight, etc. In this exhibit there were also models of diseased and healthy bolls. There were also enlarged photographs and maps, illustrating the distribution of various diseases in the United States generally and their effects as seen in the field, and large

principal lines of work pursued by these stations and the lines to which each station especially applied itself. To give a tangible and graphic idea of some of the results attained selections were made of certain important lines of work in dairying, the feeding of farm animals, and entomology.

Charts illustrating experiments in feeding farm animals were also shown, and, the most interesting and important of all, an exhibit was given illustrating the investigations of food and diet which have lately been undertaken by the office. The characteristic excess of fat in Southern rations was made evident, as was also the abundant meat diet, while the Northern fare was shown to contain more milk and starchy food. The special objects of the food work of the Department is to find out what food materials people actually buy, how much they pay for them, what nutriment they contain, and what the relation is between actual nutriment and cost. Experiments are carried on in various sections of the country, and are awakening a considerable interest in the subject among the people. This was shown by the interest with which the illustrative exhibits were examined by visitors to the Exposition, and by the numerous requests made for the explanatory bulletins.

A pleasing feature of the exhibit was the portraits of Senator J. S. Morrill, of Vermont, and Hon. W. H. Hatch, of Missouri, who, as the originators of the bills providing for the establishment and maintenance of the agricultural colleges and experiment stations, were respectively designated the "Father of the Agricultural and Mechanical Colleges" and the "Father of the Agricultural Experiment Stations."

EXHIBIT OF THE DIVISION OF PUBLICATIONS.

All this work of the Department, illustrated by the exhibits that have been described, would be of comparatively little service to the people of the country were it not for the fact that it has been embodied in a multitude of bulletins, reports, etc., which have, for the asking, been sent broadcast throughout the land. This, of course, makes the number of yearly publications by the Department something enormous, and this work is carried on by the Division of Publications, which had a modest exhibit in connection with that of the Office of Experiment Stations. This exhibit was unique in that it represented the work not only of the division itself, but of all the divisions, bureaus, and offices of the Department, the preparation of whose published reports of experiments made and results achieved it is the duty of this division to supervise.

A complete set of the publications of the Department in distinctive bindings was displayed in a handsome case, the volumes covering the period from 1837, when the Department of Agriculture had its inception as a section of the Patent Office, to June 30, 1895. An illustration in practical book making was given, embracing all the work from the

submission of the manuscript to the complete book, representing in a striking manner the manifold duties of editorial work, proof reading, and the supervision of the printing of reports, bulletins, and pamphlets of the Department. The objects exhibited comprised the original manuscript of the Yearbook for 1894 (of which 500,000 copies were issued) as edited and prepared for the printer, the galley and page proofs with the proof readers' marks thereon, the stitched volume, and the completed book, all of which were exposed to view in a glass-top case.

In this connection there were also given some samples of the various methods employed in illustrating the Department publications, embracing processes of wood engraving, photo-engraving, half-tone, lithograph, heliotype, etc., in different stages of completion from the drawing, or photograph, to the printed picture.

This division had on hand thousands of the popular pamphlets of the Department, which it distributed free to applicants. Its exhibit also served as a bureau of information, in which capacity it furnished valuable assistance to visitors by answering inquiries in connection with the exhibit of the Department.

EXHIBIT OF THE OFFICE OF ROAD INQUIRY.

Outside the Government building, occupying a space about 150 by 300 feet, was an object lesson very gratifying to those interested in the good-roads movement which is spreading so rapidly throughout the country. The Department of Agriculture has, by collecting and disseminating information on the subject, done much to further this movement, and by way of exemplifying clearly and concisely the immense advantage afforded by good roads, it built as its exhibit at the Exposition a system of parallel roadways, about 50 feet apart from center to center, including a modern macadamized road, a sand road, and a dirt road. The grades of all the roadbeds were alike, each being divided into 50-foot lengths, the first of which was level, the grade of the other lengths rising at the rate of 2 feet in every 100, 4 feet in 100, and 6 feet in 100, respectively, making each road 200 feet long. The macadam road had, in addition, two 50-foot lengths rising 8 feet in 100 and 10 feet in 100, respectively. All the roadbeds were of the natural earth found on the terrace, which was a stiff red clay, with some sand near the surface. No further preparation than that of grading was made on any of the beds except that of the macadam road. After the desired grade of this road was obtained, it was built up into a macadam pavement 6 inches deep and 12 feet wide.

On these specimen roads experiments were conducted to indicate the amount of draft on the different roads, in such manner that it could be readily observed by the spectator, and the difference of draft on good and bad roads plainly seen. This was done with the assistance of an instrument called a tractometer, which measured

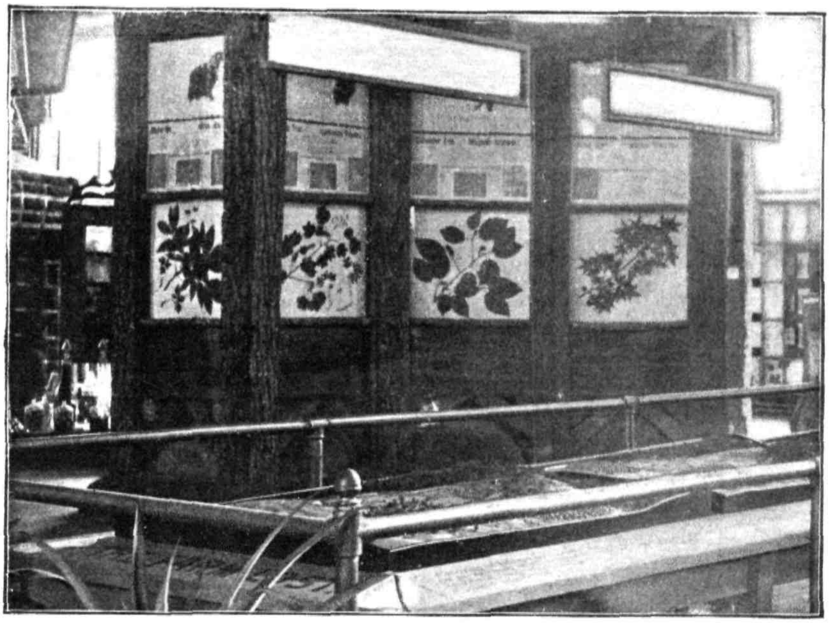


FIG. 1.—MONOGRAPHIC DISPLAY OF SOUTHERN ECONOMIC TIMBERS.

FIG. 2.—BOTANICAL DISPLAY OF SOUTHERN FOREST FLORA.

the strain of the load on the team on each of the different roads. A wagon to which the tractometer was attached was drawn up and down the roads. On the smooth road the oscillation of the pointer arm of the tractometer had a range of some 50 pounds, while on the rutted dirt road it varied from 0 to 1,500 pounds, showing that, even while exerting the same average draft, a team is subject to much less fatigue on a smooth road. The experiment also suggested the desirability of having springs on the traces, or some other means of making the change of draft more gradual at the shoulders of the team, instead of subjecting it to the violent jerks which rigid traces transmit. In a general way the draft for the same load was found to be about eight times as much on the dirt road as on the macadam, and the draft on the sand road was nearly the same as on the dirt road when muddy.

During these experiments a team of small mules readily drew 12 bales of cotton on a heavy wagon up the 10 per cent grade of the macadam road, the tractometer indicating a pull of 1,000 pounds, and the same team was completely stalled in going down the 6 per cent grade of the sand road, after pulling the indicator to 1,900 pounds. Nine bales of cotton were removed before the load could be got in motion. The driver refused to venture at all on the dirt road with the 12-bale load.

The road exhibit also afforded a test of the practical advantages of wide tires. A portion of the clay road was made thoroughly wet and a wagon with 2-inch tires and one with 4 and 5 inch tires were run over it. The result showed how much less wearing on roads are wide tires than narrow ones. That part of the road which the narrow-tired wagon traversed was cut and rutted to the depth of several inches, while the remainder was rolled by the 4 and 5 inch tires into a smooth surface.

EXHIBIT OF THE DIVISION OF FORESTRY.

Owing to its size and importance as illustrating some of our forest resources, the display of the Division of Forestry was separated from the rest of the Department exhibit and housed in a special building known as the Minerals and Forestry building. (See Pl. X.)

An interesting exhibit of wood production greeted the visitor at the very entrance to this exhibit. It was a statistical pyramid formed of blocks intended to show graphically the amount of wood material furnished by the forest resources of the South for every second in the year. The base block, containing about 300 cubic feet and representing the entire amount of wood of all kinds and for all purposes, such as fuel, fencing, railroad ties, lumber, etc., indicated an annual consumption of about 10,000,000,000 cubic feet. A smaller block, of 48 cubic feet content, resting upon the base block, represented the amount of log material for lumber, timber, and bolt-size material cut per second, and indicated an annual output for all kinds of

1,500,000,000 cubic feet of logs, corresponding to over 10,000,000,000 feet, B. M. One of the interesting facts shown by this particular exhibit was that the two hard-wood-producing States, Tennessee and Kentucky, cut a larger proportion than the pine States. It was also demonstrated that the South furnishes so far only one-quarter of the cut timber of the country, notwithstanding it still contains larger areas and the largest amount of standing timber, excepting the Pacific Coast, which is estimated to possess 1,000,000,000,000 feet of standing timber, B. M., while the Southern States possess 700,000,000,000 feet of standing timber.

The forest geography of the South was shown by a series of maps, each representing one of the Southern States and showing by colors the character of the forest growth in various portions of the State. Each map showed the distribution of broad-leafed and coniferous species, and to some extent the density of existing forests.

One of the most interesting displays served to show the farmer in a very graphic manner the costliness of a lack of judgment in making his clearings. The unintelligent denudation of the hillsides, in a country of large and precipitous rainfall, has caused, under careless cultivation, an erosion of these lands which has turned thousands of acres of tillable lands into wastes, furrowed and gullied and denuded of its fertile soil. To bring home an object lesson of such irrational treatment, and to illustrate the methods of reclaiming these waste lands and the possibilities of an improved agriculture on all the eroded soils of the South, a set of three relief models of an eroded farm was shown. (See figs. 80, p. 334; 81, p. 335; 82, p. 336.)

To accentuate this object lesson, a large relief map of the Holy Land, bearing the inscription, "The land where once milk and honey flowed," was hung up over these farm models, and it was further shown that trees so wastefully cut as to destroy the forest in a very few years require many years to again produce material fit for the saw. This important fact was illustrated by a section of longleaf pine, the ring growth of which indicates an age of 372 years.

The entire arborescent forest flora of the United States, comprising, among the richest and most varied species on the continent, representatives of 53 families, 136 genera, and nearly 300 species, were displayed by a series of panels requiring not less than one thousand square feet of wall space, each species being represented by botanical specimens, with flower and fruit, a wood section of the bark, and a label with a map giving the field distribution, the characteristics of growth, and the uses of its wood.

One of the most attractive displays was that of ornamental woods. While the beauty of the tropical and semitropical woods lies in their rich warm colors, as could be seen in the exhibit of Argentina, near by, the beauty of North American woods was shown to lie mostly in their variegated grain. Yet, as the polished woods exhibited by the State

of Arkansas showed, the variety of color of our woods would suffice even in that respect for all ornamental needs.

The one great thing, however, in which our timbers excel those of the tropics was shown to be their general serviceableness in construction. Within the last four years the Department of Agriculture, through its Division of Forestry, has undertaken a systematic study of the properties of our more important timbers, the work being designated "Timber physics." These studies were illustrated by a very complete arrangement of specimens in small sizes as well as large beams and columns, which had been tested at the laboratory, and others which were designed to show the relative strength of various timbers. Large tested columns and beams, built up in trestle form, and also tension and cross breaking specimens, were so combined as to illustrate the comparative ability of the different species to resist the various loads and strains to which timber is subjected.

The Division of Forestry has proved by a series of careful tests that timber bled for turpentine is in no way impaired in strength or durability. The erroneous notion that it is has not only prevailed for a long time among engineers, architects, and woodsmen in general, but some of them have even gone so far as to claim that they could recognize the timber which came from bled trees. To show the impossibility of this, a series of sections, selected from both bled and unbled trees, were exhibited for venturesome guessers.

The "Story of the Knot" was told on a panel, showing the gradual development of these blemishes of lumber. Few lumbermen even know that all knots originate in the very center of the tree, where all branch growth begins, and that, therefore, in order to produce clear timber, trees must be grown closely together, so that the side branches may soon die from lack of light and break off, the very heart only remaining knotty as the result of the broken-off limbs. Other defects commonly found in lumber, such as dry rot, pegginess, moon rings, wind shakes, etc., were shown in a special collection of cuts. A small section of the exhibit was also devoted to the illustrations of the various by-products which the Southern forests furnish, including sugar production from the maple, and an illustration of the turpentine industry, which received the largest share of attention; all the latest tools and methods employed at present in securing these products of the forest were displayed.

In order to illustrate the beauties of grain in the cypress, a large log was cut into unedged boards, half of them 1 inch and the other half 2 inches in thickness. These were arranged fan shape, permitting an examination of the material from the slab to the center cut, and illustrating the usual method of sawing. One surface of each piece was finished smooth; the other was left as it came from the saw.

An exhibit of hickory handles was one of the most satisfactory of the entire display. It included sections of hickory logs, showing the

shape in which the material was received at the factory, with split bolts also. From these raw materials the several stages of manufacture, as turned out by the various machines, were arranged in consecutive order; ax, pick, hatchet, and many kinds of hammer handles were thus illustrated, giving the visitor a comprehensive idea of the methods of manufacture. When it is known that a single handle factory uses fifty cords of the best hickory wood a day, the magnitude of this industry becomes apparent. In the same manner the manufacture of wagon stock and oak furniture was illustrated. The manufacture of veneer goods was shown, and the use of persimmon and dogwood in the manufacture of shuttles and bobbins, the great oak-stave and cooperage industry, the importance of wood in organ and piano making, and many other lines of manufacture were suggestively displayed, giving to this section of the exhibit an unusual interest.

In this comprehensive exhibit of the forestry work of the Department the educational idea was, for the first time in America, made superior to the commercial in an important exhibit showing natural resources and extent of exportation, and the interest excited proved the utility and success of the method.

If the foregoing account of some of the most important exhibits of the Department gives the reader an idea of the nature, purpose, and scope of the work of the Department of Agriculture, it will have served its purpose.

APPENDIX.[1]

ORGANIZATION OF THE DEPARTMENT OF AGRICULTURE.

[Location, The Mall, between Twelfth and Fourteenth streets.]

SECRETARY OF AGRICULTURE, J. Sterling Morton.

The Secretary of Agriculture is charged with the supervision of all public business relating to the agricultural industry. He appoints all the officers and employees of the Department, with the exception of the Assistant Secretary and the Chief of the Weather Bureau, who are appointed by the President, and directs the management of all the divisions, offices, and bureaus embraced in the Department. He exercises advisory supervision over the agricultural experiment stations deriving support from the national Treasury, and has control of the quarantine stations for imported cattle, and of interstate quarantine rendered necessary by contagious cattle diseases.

ASSISTANT SECRETARY, Chas. W. Dabney, jr.

The Assistant Secretary performs such duties as may be prescribed by the Secretary. To his office has been assigned the control and direction of the scientific policy and operations of the following divisions and offices: The Divisions of Botany, Vegetable Physiology and Pathology, Agrostology, Pomology, Chemistry, Economic Ornithology and Mammalogy, Entomology, and Agricultural Soils; the Office of Experiment Stations, the Office of Irrigation Inquiry, and the Office of Fiber Investigations; and the Department Museum.

CHIEF CLERK, D. MacCuaig.

The Chief Clerk has the general supervision of the clerks and employees; of the order of business, records, and correspondence of the Secretary's office; of all expenditures from appropriations for contingent expenses, stationery, etc.; of the enforcement of the general regulations of the Department, and of the buildings occupied by the Department of Agriculture.

LIBRARIAN, W. P. Cutter.

BUREAUS AND DIVISIONS.

WEATHER BUREAU (corner Twenty-fourth and M streets NW.).—*Chief*, Willis L. Moore; *assigned as Assistant Chief*, Maj. H. H. C. Dunwoody, U. S. A.; *Chief Clerk*, James R. Cook; *Professors of Meteorology*, Cleveland Abbe, F. H. Bigelow, Charles F. Marvin, Edward B. Garriott.

The Weather Bureau has charge of the forecasting of weather; the issue of storm warnings; the display of weather and flood signals for the benefit of agriculture, commerce, and navigation; the gauging and reporting of rivers; the maintenance and operation of seacoast telegraph lines, and the collection and transmission of marine intelligence for the benefit of commerce and navigation; the reporting of temperature and rainfall conditions for the cotton, rice, sugar, and other interests; the display of frost and cold-wave signals; the distribution of meteorological information in the interests of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties.

[1] For subject-matter of appendix, see under Contents, p. 5.

BUREAU OF ANIMAL INDUSTRY.—*Chief*, D. E. Salmon; *Assistant Chief*, G. M. Brumbaugh.

The Bureau of Animal Industry makes investigations as to the existence of contagious pleuro-pneumonia and other dangerous communicable diseases of live stock, superintends the measures for their extirpation, makes original investigations as to the nature and prevention of such diseases, and reports on the condition and means of improving the animal industries of the country. It also has charge of the inspection of import and export animals, of the inspection of vessels for the transportation of export cattle, and of the quarantine stations for imported neat cattle; supervises the interstate movement of cattle, and inspects live stock and their products slaughtered for food consumption. The work of the Bureau is assigned to the following divisions: Division of Animal Pathology, Inspection Division, Division of Field Investigations and Miscellaneous Work, and Dairy Division.

DIVISION OF STATISTICS.—*Statistician*, Henry A. Robinson; *Assistant Statistician*, Henry Farquhar.

The Division of Statistics collects information as to the condition, prospects, and harvests of the principal crops, and of the numbers and status of farm animals, through a corps of county correspondents and the aid of a supplementary organization under the direction of State agents, and obtains similar information from European countries monthly through the deputy consul-general at London, assisted by consular, agricultural, and commercial authorities. It records, tabulates, and coordinates statistics of agricultural production, distribution, and consumption, the authorized data of governments, institutes, societies, boards of trade, and individual experts, and issues a monthly crop report and occasional bulletins for the information of producers and consumers, and for their protection against combination and extortion in the handling of the products of agriculture.

OFFICE OF EXPERIMENT STATIONS.—*Director*, A. C. True; *Assistant Director*, E. W. Allen.

The Office of Experiment Stations represents the Department in its relations to the experiment stations which are now in operation in all the States and Territories. It seeks to promote the interests of agricultural education and investigation throughout the United States. It collects and disseminates general information regarding the colleges and stations, and publishes accounts of agricultural investigations at home and abroad. It also indicates lines of inquiry, aids in the conduct of cooperative experiments, reports upon the expenditures and work of the stations, and in general furnishes them with such advice and assistance as will best promote the purposes for which they were established. It is also charged with investigations on the nutritive value and economy of human foods.

DIVISION OF CHEMISTRY.—*Chief Chemist*, Harvey W. Wiley; *First Assistant Chemist*, W. G. Brown.

The Division of Chemistry makes investigations of the methods proposed for the analyses of soils, fertilizers, and agricultural products, and such analyses as pertain in general to the interests of agriculture. It can not undertake the analyses of samples of the above articles of a miscellaneous nature, but application for such analyses should be made to the directors of the agricultural experiment stations of the different States. The division does not make assays of ores nor analyses of minerals except when related to general agricultural interests, nor analyses of water.

DIVISION OF ENTOMOLOGY.—*Entomologist*, L. O. Howard; *First Assistant Entomologist*, C. L. Marlatt.

The Division of Entomology obtains and disseminates information regarding insects injurious to vegetation; investigates insects sent to the division in order to give appropriate remedies; conducts investigations of this character in different parts of the country; and mounts and arranges specimens for illustrative and museum purposes.

DIVISION OF ORNITHOLOGY AND MAMMALOGY.—*Ornithologist*, C. Hart Merriam; *First Assistant Ornithologist*, T. S. Palmer.

The Division of Ornithology and Mammalogy studies the geographic distribution of animals and plants, and maps the natural life zones of the country; it also investigates the economic relations of birds and mammals, and recommends measures for the preservation of beneficial and destruction of injurious species.

DIVISION OF FORESTRY.—*Chief*, B. E. Fernow; *Assistant Chief*, Charles A. Keffer.

The Division of Forestry is occupied with experiments, investigations, and reports dealing with the subject of forestry, and with the dissemination of information upon forestry matters.

DIVISION OF BOTANY.—*Botanist*, Frederick V. Coville; *First Assistant Botanist*, J. N. Rose.

The Division of Botany maintains the National Herbarium, publishes information on the treatment of weeds, experiments with poisonous and medicinal plants, tests seeds with a view to their increased purity and commercial value, and investigates other questions of economic botany.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.—*Chief*, B. T. Galloway; *First Assistant*, Albert F. Woods.

The Division of Vegetable Physiology and Pathology has for its object a study of the normal and abnormal life processes of plants. It seeks by investigations in the field and experiments in the laboratory to determine the causes of disease and the best means of preventing the same. It studies plant physiology in its bearing on pathology.

DIVISION OF AGROSTOLOGY.—*Chief*, F. Lamson-Scribner; *First Assistant*, Jared G. Smith.

The Division of Agrostology is charged with the investigation of the natural history, geographical distribution, and uses of grasses and forage plants, their adaptation to special soils and climates, the introduction of promising native and foreign kinds into cultivation, and the preparation of publications and correspondence relative to these plants.

DIVISION OF POMOLOGY.—*Pomologist*, Samuel B. Heiges; *Assistant Pomologist*, W. A. Taylor.

The Division of Pomology collects and distributes information in regard to the fruit interests of the United States; investigates the habits and peculiar qualities of fruits, their adaptability to various soils and climates, and conditions of culture, and introduces new and untried fruits from foreign countries.

DIVISION OF AGRICULTURAL SOILS.—*Chief*, Milton Whitney.

The Division of Agricultural Soils has for its object the investigation of the texture and other physical properties of soils and their relation to crop production.

OFFICE OF FIBER INVESTIGATIONS.—*Special Agent in Charge*, Chas. Richards Dodge.

The Office of Fiber Investigations collects and disseminates information regarding the cultivation of textile plants, directs experiments in the culture of new and hitherto unused plants, and investigates the merits of new machines and processes for preparing them for manufacture.

OFFICE OF IRRIGATION INQUIRY.—*Chief*, Charles W. Irish.

The Office of Irrigation Inquiry collects and publishes information regarding the best modes of agriculture by irrigation.

OFFICE OF ROAD INQUIRY.—*Special Agent in Charge*, Roy Stone.

The Office of Road Inquiry collects information concerning the systems of road management throughout the United States, conducts investigations regarding the best method of road making, and prepares publications on this subject.

GARDENS AND GROUNDS.—*Horticulturist and Superintendent of Gardens and Grounds*, William Saunders.

The Division of Gardens and Grounds is charged with the care and ornamentation of the park surrounding the Department buildings, and with the duties connected with the conservatories and gardens for testing and propagating economic plants.

DIVISION OF PUBLICATIONS.—*Chief*, Geo. Wm. Hill; *Assistant Chief*, Joseph A. Arnold.

The Division of Publications has entire supervision of the printing and publishing of the Department, and is especially charged with the preparation, publication, and distribution of farmers' bulletins. It also has general supervision of the work of illustrations. The division issues advance notices and a monthly list of publications, and prepares for publication any information of special interest to agriculturists.

DIVISION OF ACCOUNTS AND DISBURSING OFFICE.—*Chief*, Frank L. Evans; *Assistant Disbursing Officer* (in charge of Weather Bureau disbursements), A. Zappone; *Cashier*, Everett D. Yerby.

This office is charged with the adjustment of all claims against the Department; decides questions involving the expenditure of public funds; prepares contracts for annual supplies, leases, and agreements; issues requisitions for the purchase of supplies, requests for passenger and freight transportations, and attends to all business relating to the financial interests of the Department, including payments of every description.

STATISTICS OF THE PRINCIPAL CROPS.

Acreage, production, and value of corn and wheat in 1895.

States and Territories.	Corn.			Wheat.		
	Acres.	Bushels.	Value.	Acres.	Bushels.	Value.
Maine	14,212	596,904	$322,328	4,365	83,808	$68,723
New Hampshire	26,854	1,079,531	550,561	2,494	48,134	36,582
Vermont	47,225	2,153,460	1,033,661	6,382	185,078	127,704
Massachusetts	42,078	1,847,224	960,556	------	------	------
Rhode Island	9,217	284,805	159,491	------	------	------
Connecticut	46,658	1,768,338	901,852	------	------	------
New York	506,016	18,014,170	8,106,377	403,374	7,301,069	4,964,727
New Jersey	279,788	9,233,004	3,877,862	108,139	1,340,924	952,056
Pennsylvania	1,298,886	43,512,681	16,969,946	1,232,315	20,456,429	13,296,679
Delaware	203,871	4,281,291	1,455,639	92,181	1,069,300	684,352
Maryland	616,836	16,531,205	6,116,546	458,868	7,800,756	4,992,484
Virginia	1,753,073	32,607,158	12,064,648	699,525	6,505,583	4,228,629
North Carolina	2,508,856	36,378,412	13,823,797	688,196	4,748,552	3,418,957
South Carolina	1,789,271	19,860,908	9,136,018	134,160	858,624	755,589
Georgia	3,244,037	42,172,481	17,290,717	214,630	1,330,706	1,091,179
Florida	552,379	6,186,645	2,907,723	------	------	------
Alabama	2,790,974	44,376,487	16,419,300	49,771	373,283	298,626
Mississippi	2,277,036	35,977,169	13,311,553	4,648	37,184	22,682
Louisiana	1,247,198	22,574,284	9,029,714	------	------	------
Texas	4,087,332	107,905,565	33,450,725	365,290	2,081,640	1,373,882
Arkansas	2,342,305	50,359,558	16,115,059	154,500	1,452,300	856,857
Tennessee	3,325,321	83,133,025	22,445,917	655,310	5,766,728	3,575,371
West Virginia	688,545	16,662,789	6,665,116	406,017	4,303,780	2,969,608
Kentucky	3,010,876	93,939,331	25,363,619	871,672	9,501,225	5,795,747
Ohio	2,846,110	92,783,186	25,051,460	2,422,224	32,215,579	19,329,347
Michigan	994,090	33,600,242	10,752,077	1,154,379	15,237,803	9,142,682
Indiana	3,702,310	121,435,768	27,930,227	2,205,923	20,294,492	11,567,860
Illinois	6,821,833	255,136,554	56,130,042	1,732,792	19,060,712	10,102,177
Wisconsin	1,040,676	33,093,497	9,928,049	555,885	8,616,218	4,394,271
Minnesota	1,152,458	35,956,690	7,191,338	2,851,485	65,584,155	28,857,028
Iowa	8,504,349	298,502,650	53,730,477	700,245	13,654,778	6,281,198
Missouri	6,613,118	238,072,248	47,614,450	1,541,664	18,499,968	9,434,984
Kansas	8,426,327	204,759,746	38,904,352	2,976,567	22,919,566	10,313,805
Nebraska	7,806,526	125,685,069	22,623,312	1,232,252	14,787,024	5,914,810
South Dakota	1,119,229	12,423,442	2,857,392	2,438,424	29,261,088	11,119,213
North Dakota	30,938	658,979	158,155	2,907,510	61,057,710	23,201,930
Montana	1,331	33,275	24,956	44,570	1,065,223	777,613
Wyoming	2,483	68,283	38,921	7,623	198,198	126,847
Colorado	178,308	3,690,976	1,513,300	119,500	2,808,250	1,572,620
New Mexico	26,956	733,208	410,594	39,669	809,248	590,751
Arizona	5,105	132,730	99,548	12,227	250,654	162,925
Utah	8,918	181,035	88,707	109,086	2,443,526	1,075,151
Nevada	------	------	------	5,651	122,627	60,087
Idaho	1,656	50,839	31,520	68,646	1,221,899	574,293
Washington	5,454	93,263	37,305	464,255	7,195,952	2,950,340
Oregon	13,395	353,628	194,495	593,136	11,862,720	5,575,478
California	65,416	2,256,852	1,196,132	3,084,446	40,097,798	24,058,679
Oklahoma	------	------	------	227,426	2,592,656	1,244,475
Total	82,075,830	2,151,138,580	544,985,534	34,047,332	467,102,947	237,938,998

Production and exports of corn since 1893.

Year.	Total area of crop.	Total production.	Total value of crop.	Value per bushel.	Yield per acre.	Value per acre.	Exports for fiscal years beginning July 1.	
	Acres.	*Bushels.*	*Dollars.*	*Cents.*	*Bushels.*	*Dolls.*	*Bushels.*	*Per ct.*
1893	72,036,465	1,619,496,131	591,625,627	36.5	22.5	8.21	66,489,529	4.1
1894	62,582,269	1,212,770,052	554,719,162	45.7	19.4	8.86	28,585,405	2.4
1895	82,075,830	2,151,138,580	544,985,534	25.3	26.2	6.64	----	----

Production and exports of wheat since 1893.

Year.	Total area of crop.	Total production.	Total value of crop.	Value per bushel.	Yield per acre.	Value per acre.	Exports for fiscal years beginning July 1.	
	Acres.	*Bushels.*	*Dollars.*	*Cents.*	*Bushels.*	*Dolls.*	*Bushels.*	*Per ct.*
1893	34,629,418	396,131,725	213,171,381	53.8	11.4	6.16	164,283,129	41.5
1894	34,882,436	460,267,416	225,902,025	49.1	13.2	6.48	144,812,718	31.5
1895	34,047,332	467,102,947	237,938,998	50.9	13.7	6.99	----	----

Disposition of the corn crop of 1895.

States and Territories.	Crop of 1895.	Stock on hand Mar. 1, 1896.		Retained and consumed in county where grown.		Shipped out of county where grown.	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Maine	597,000	208,950	35	597,000	100	----	----
New Hampshire	1,080,000	356,400	33	1,080,000	100	----	----
Vermont	2,153,000	968,850	45	2,153,000	100	----	----
Massachusetts	1,847,000	609,510	33	1,847,000	100	----	----
Rhode Island	285,000	128,250	45	285,000	100	----	----
Connecticut	1,768,000	654,160	37	1,768,000	100	----	----
New York	18,014,000	7,565,880	42	17,293,440	96	720,560	4
New Jersey	9,233,000	3,877,860	42	8,217,370	89	1,015,630	11
Pennsylvania	43,513,000	16,970,070	39	36,986,050	85	6,526,950	15
Delaware	4,281,000	2,054,880	48	2,568,600	60	1,712,400	40
Maryland	16,531,000	7,273,640	44	11,241,080	68	5,289,920	32
Virginia	32,607,000	13,368,870	41	27,715,950	85	4,891,050	15
North Carolina	36,378,000	18,552,780	51	33,467,760	92	2,910,240	8
South Carolina	19,861,000	10,129,110	51	19,066,560	96	794,440	4
Georgia	42,173,000	24,038,610	57	39,220,890	93	2,952,110	7
Florida	6,187,000	3,093,500	50	5,444,560	88	742,440	12
Alabama	44,376,000	22,188,000	50	39,494,640	89	4,881,360	11
Mississippi	35,977,000	21,586,200	60	34,178,150	95	1,798,850	5
Louisiana	22,574,000	12,189,960	54	21,896,780	97	677,220	3
Texas	107,906,000	51,794,880	48	94,957,280	88	12,948,720	12
Arkansas	50,360,000	25,180,000	50	47,338,400	94	3,021,600	6
Tennessee	83,133,000	43,229,160	52	66,506,400	80	16,626,600	20
West Virginia	16,663,000	6,831,830	41	15,829,850	95	833,150	5
Kentucky	93,939,000	46,969,500	50	79,848,150	85	14,090,850	15
Ohio	92,783,000	37,113,200	40	70,515,080	76	22,267,920	24
Michigan	33,600,000	11,088,000	33	31,584,000	94	2,016,000	6
Indiana	121,436,000	55,860,560	46	91,077,000	75	30,359,000	25
Illinois	255,137,000	132,671,240	52	163,287,680	64	91,849,320	36
Wisconsin	33,094,000	11,582,900	35	31,108,360	94	1,985,640	6
Minnesota	35,957,000	17,618,930	49	32,001,730	89	3,955,270	11
Iowa	298,503,000	164,176,650	55	202,982,040	68	95,520,960	32
Missouri	238,072,000	138,081,760	58	180,934,720	76	57,137,280	24
Kansas	204,760,000	100,332,400	49	153,570,000	75	51,190,000	25
Nebraska	125,685,000	57,815,100	46	94,263,750	75	31,421,250	25
South Dakota	12,423,000	3,975,360	32	11,304,930	91	1,118,070	9
North Dakota	659,000	210,880	32	645,820	98	13,180	2
Montana	33,000	3,960	12	33,000	100	----	----
Wyoming	68,000	13,600	20	68,000	100	----	----
Colorado	3,691,000	848,930	23	3,617,180	98	73,820	2
New Mexico	733,000	293,200	40	689,020	94	43,980	6
Arizona	133,000	29,260	22	113,050	85	19,950	15
Utah	181,000	32,580	18	175,570	97	5,430	3
Idaho	51,000	8,160	16	51,000	100	----	----
Washington	93,000	19,530	21	81,840	88	11,160	12
Oregon	354,000	67,260	19	346,920	98	7,080	2
California	2,257,000	609,390	27	1,805,600	80	451,400	20
Total	2,151,139,000	1,072,273,700	49.8	1,679,258,200	78.1	471,880,800	21.9

Disposition of the wheat crop of 1895.

States and Territories.	Crop of 1895.	Stock on hand Mar. 1, 1896.		Consumed in county where grown.		Shipped out of county where grown.	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Maine	84,000	37,800	45	84,000	100	----	----
New Hampshire	48,000	14,400	30	48,000	100	----	----
Vermont	185,000	64,750	35	185,000	100	----	----
New York	7,301,000	2,920,400	40	4,818,660	66	2,482,340	34
New Jersey	1,341,000	402,300	30	1,086,210	81	254,790	19
Pennsylvania	20,456,000	7,568,720	37	12,478,160	61	7,977,840	39
Delaware	1,069,000	299,320	28	694,850	65	374,150	35
Maryland	7,801,000	1,716,220	22	2,964,380	38	4,836,620	62
Virginia	6,506,000	1,756,620	27	3,448,180	53	3,057,820	47
North Carolina	4,748,000	1,471,880	31	4,558,080	96	189,920	4
South Carolina	859,000	197,570	23	850,410	99	8,590	1
Georgia	1,331,000	252,890	19	1,277,760	96	53,240	4
Alabama	373,000	41,030	11	361,810	97	11,190	3
Mississippi	37,000	9,250	25	36,260	98	740	2
Texas	2,082,000	291,480	14	1,519,860	73	562,140	27
Arkansas	1,452,000	450,120	31	1,118,040	77	333,960	23
Tennessee	5,767,000	1,211,070	21	3,575,540	62	2,191,460	38
West Virginia	4,304,000	1,291,200	30	3,357,120	78	946,880	22
Kentucky	9,501,000	2,185,230	23	5,130,540	54	4,370,460	46
Ohio	32,216,000	10,309,120	32	16,752,320	52	15,463,680	48
Michigan	15,238,000	4,419,020	29	7,161,860	47	8,076,140	53
Indiana	20,294,000	5,073,500	25	9,335,240	46	10,958,760	54
Illinois	19,061,000	4,193,420	22	7,815,010	41	11,245,990	59
Wisconsin	8,616,000	3,791,040	44	6,462,000	75	2,154,000	25
Minnesota	65,584,000	19,675,200	30	17,051,840	26	48,532,160	74
Iowa	13,655,000	6,008,200	44	8,739,200	64	4,915,800	36
Missouri	18,500,000	4,810,000	26	8,325,000	45	10,175,000	55
Kansas	22,919,000	4,583,800	20	11,001,120	48	11,917,880	52
Nebraska	14,787,000	5,619,060	38	7,984,980	54	6,802,020	46
South Dakota	29,261,000	6,730,030	23	8,485,690	29	20,775,310	71
North Dakota	61,058,000	12,822,180	21	10,379,860	17	50,678,140	83
Montana	1,065,000	426,000	40	1,065,000	100	----	----
Wyoming	198,000	59,400	30	178,200	90	19,800	10
Colorado	2,808,000	533,520	19	1,965,600	70	842,400	30
New Mexico	809,000	242,700	30	728,100	90	80,900	10
Arizona	251,000	65,260	26	223,390	89	27,610	11
Utah	2,443,000	879,480	36	1,587,950	65	855,050	35
Nevada	123,000	49,200	40	111,930	91	11,070	9
Idaho	1,222,000	366,600	30	574,340	47	647,660	53
Washington	7,196,000	1,583,120	22	2,158,800	20	5,037,200	70
Oregon	11,863,000	3,203,010	27	4,863,830	41	6,999,170	59
California	40,098,000	5,212,740	13	11,227,440	28	28,870,560	72
Oklahoma	2,593,000	207,440	8	1,970,680	76	622,320	24
Total	467,103,000	123,045,290	26.3	193,742,240	41.5	273,360,760	58.5

Changes in crop area.

The following table shows the number of acres devoted to certain principal crops for every 1,000 acres of improved land in 1879 and 1889, as determined by the Tenth and Eleventh censuses:

Crop.	1879.	1889.	Increase or decrease.	Crop.	1879.	1889.	Increase or decrease.
	Acres.	*Acres.*	*Acres.*		*Acres.*	*Acres.*	*Acres.*
Corn	219.0	201.6	Decrease .. 17.4	Hay	107.6	148.1	Increase ... 40.5
Wheat	124.4	93.9	Decrease .. 30.5	Cotton	50.7	56.2	Increase ... 5.5
Oats	56.7	79.2	Increase .. 22.5				
Barley	7.0	9.0	Increase .. 2.0	Total area in these products.	574.9	596.5	Net increase 21.6
Rye	6.5	6.1	Decrease .. .4				
Buckwheat	3.0	2.4	Decrease .. .6				

It is thus shown that for every 1,000 acres of improved land in 1889 there were 48.9 fewer acres in corn, wheat, rye, and buckwheat, and 70.5 more in oats, hay, barley, and cotton than for the corresponding area in 1879.

Acreage, production, and value of oats and barley in 1895.

States and Territories.	Oats.			Barley.		
	Acres.	Bushels.	Value.	Acres.	Bushels.	Value.
Maine	138,441	5,551,484	$1,887,505	12,607	408,467	$212,403
New Hampshire	29,651	1,094,122	382,943	5,335	136,576	76,483
Vermont	116,452	5,100,598	1,683,197	18,668	619,778	291,296
Massachusetts	15,274	549,864	186,954	1,839	41,378	26,896
Rhode Island	3,765	121,986	47,575	381	8,954	6,716
Connecticut	23,267	742,217	230,087			
New York	1,440,579	45,666,354	12,786,579	239,005	5,473,215	4,433,304
New Jersey	107,561	3,818,416	1,107,341			
Pennsylvania	1,152,565	36,536,311	9,864,804	12,814	258,843	106,126
Delaware	24,544	468,790	135,949			
Maryland	88,550	2,320,010	626,403			
Virginia	459,043	8,125,061	2,437,518			
North Carolina	506,777	7,652,333	2,907,887			
South Carolina	288,837	4,390,322	2,151,258			
Georgia	460,624	6,679,048	3,072,362			
Florida	39,836	406,327	264,113			
Alabama	349,676	5,210,172	2,188,272			
Mississippi	132,281	2,076,812	809,957			
Louisiana	38,383	575,745	207,268			
Texas	703,825	14,569,178	3,787,986	2,484	53,654	28,973
Arkansas	327,027	8,306,486	2,658,076			
Tennessee	454,887	10,234,958	2,763,439	2,491	57,542	28,771
West Virginia	151,253	3,539,320	1,132,582			
Kentucky	505,819	13,252,458	3,445,639	2,672	88,978	33,812
Ohio	990,678	31,404,493	6,908,988	29,244	824,681	338,119
Michigan	973,439	23,265,192	5,350,994	69,356	1,255,344	539,798
Indiana	1,130,812	25,895,595	5,179,119	6,811	102,165	40,866
Illinois	3,020,784	73,707,130	12,530,212	17,645	352,900	158,805
Wisconsin	1,864,505	63,020,269	11,343,648	370,938	10,868,483	3,695,284
Minnesota	1,954,764	77,995,084	10,919,312	484,369	17,437,284	4,184,948
Iowa	3,960,332	182,967,338	25,615,427	453,031	12,684,868	2,917,520
Missouri	1,102,805	30,547,699	5,498,586	940	14,382	6,903
Kansas	1,680,223	30,075,992	5,112,919	17,942	258,365	59,424
Nebraska	1,676,962	39,911,696	5,587,637	49,051	1,393,048	334,332
South Dakota	717,580	18,154,774	3,122,621	130,445	2,543,678	483,299
North Dakota	594,016	19,067,914	3,050,866	290,766	8,839,286	1,767,857
Montana	68,326	2,446,071	1,076,271	5,701	142,525	84,090
Wyoming	14,175	581,175	226,658			
Colorado	98,812	3,389,252	948,991	14,290	447,277	268,366
New Mexico	9,869	393,773	177,198	1,852	51,856	35,262
Arizona				10,165	261,241	182,869
Utah	27,407	926,357	277,907	6,366	190,980	74,482
Nevada				8,180	262,578	131,289
Idaho	31,317	1,102,358	319,684	10,606	259,847	109,136
Washington	91,116	3,671,975	1,028,153	52,070	1,942,211	738,040
Oregon	251,423	7,240,982	1,955,065	34,782	768,682	307,473
California	60,144	1,690,046	659,118	937,127	19,023,678	7,609,471
Total	27,878,406	824,443,537	163,655,068	3,299,973	87,072,744	29,312,413

Production of oats since 1893.

Year.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1893	638,854,850	27,273,033	187,567,092	29.4	23.4	6.88
1894	662,036,928	27,023,553	214,816,920	32.4	24.5	7.95
1895	824,443,537	27,878,406	163,655,068	19.9	29.6	5.87

Our exports of oats (including oatmeal reduced at the rate of 18 pounds to the bushel) rarely exceed 1 per cent of the total crop, the highest ratio, nearly 2 per cent for the fiscal year 1889-90, having followed the very large crop of 1889, the largest recorded until 1895. The export of oatmeal during the six months ending December, 1895, exceeded that of any entire fiscal year since 1886.

The barley acreage in 1895 was the largest on record, and the average yield per acre was the highest in a quarter century.

Wheat crop of the world, 1891 to 1895.

Countries.	1891.	1892.	1893.	1894.	1895.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
United States	611,780,000	515,949,000	396,132,000	460,267,000	467,103,000
Canada	62,635,000	49,701,000	42,650,000	44,583,000	57,460,000
Mexico	15,000,000	14,000,000	15,000,000	18,000,000	14,000,000
Total North America	689,415,000	579,650,000	453,782,000	522,850,000	538,563,000
Argentina	32,000,000	36,000,000	57,000,000	80,000,000	60,000,000
Uruguay	2,805,000	3,292,000	5,703,000	8,915,000	10,000,000
Chile	18,000,000	16,500,000	19,000,000	16,000,000	15,000,000
Total South America	52,805,000	55,792,000	81,703,000	104,915,000	85,000,000
Austria	41,074,000	50,174,000	43,660,000	48,190,000	41,200,000
Hungary	139,294,000	142,558,000	158,425,000	141,858,000	146,000,000
Croatia-Slavonia	6,597,000	7,071,000	8,223,000	8,786,000	6,200,000
Bosnia-Herzegovina	1,800,000	2,000,000	2,000,000	2,000,000	2,000,000
Montenegro	220,000	250,000	250,000	250,000	220,000
Servia	8,000,000	10,000,000	8,651,000	7,500,000	9,400,000
Roumania	48,491,000	63,942,000	60,115,000	43,587,000	68,503,000
Turkey in Europe	22,500,000	29,000,000	20,000,000	20,000,000	21,500,000
Bulgaria	40,902,000	40,441,000	35,987,000	30,600,000	37,000,000
Greece	5,675,000	4,500,000	6,500,000	5,500,000	4,000,000
Italy	141,466,000	115,685,000	135,227,000	121,595,000	106,181,000
Spain	71,349,000	82,288,000	93,484,000	105,600,000	92,000,000
Portugal	7,000,000	6,000,000	5,500,000	9,000,000	7,000,000
France	219,261,000	310,836,000	277,509,000	347,537,000	339,129,000
Switzerland	2,500,000	4,000,000	3,300,000	4,500,000	5,000,000
Germany	85,750,000	116,215,000	110,040,000	110,681,000	110,000,000
Belgium	16,500,000	19,500,000	17,300,000	19,800,000	18,000,000
Netherlands	3,504,000	5,380,000	4,971,000	4,346,000	5,000,000
Great Britain	74,401,000	60,407,000	50,800,000	61,038,000	38,348,000
Ireland	2,615,000	2,214,000	1,666,000	1,532,000	1,109,000
Denmark	4,666,000	4,964,000	4,661,000	4,162,000	4,500,000
Sweden	4,341,000	4,343,000	3,893,000	4,467,000	3,798,000
Norway	250,000	250,000	275,000	275,000	260,000
Russia in Europe	253,576,000	337,570,000	461,861,000	418,225,000	376,885,000
Total Europe	1,201,732,000	1,410,588,000	1,514,298,000	1,521,029,000	1,443,233,000
Russia in Asia	64,747,000	72,000,000	76,997,000	87,608,000	83,499,000
British India	256,704,000	206,640,000	268,539,000	252,784,000	234,379,000
Asiatic Turkey	45,000,000	44,000,000	48,000,000	45,000,000	46,000,000
Persia	20,630,000	18,567,000	20,000,000	22,000,000	22,000,000
Japan	18,277,000	15,741,000	16,848,000	16,000,000	16,560,000
Cyprus	2,000,000	2,000,000	2,000,000	2,000,000	2,200,000
Total Asia	407,358,000	358,948,000	432,384,000	425,392,000	404,578,000
Egypt	11,140,000	8,252,000	10,000,000	12,000,000	14,000,000
Tunis	7,000,000	8,000,000	4,005,000	10,700,000	7,500,000
Algeria	26,184,000	19,979,000	20,274,000	28,900,000	24,800,000
Cape Colony	2,813,000	3,500,000	4,014,000	3,195,000	2,542,000
Total Africa	47,137,000	39,731,000	38,288,000	54,795,000	48,842,000
New South Wales	3,764,000	4,089,000	7,032,000	6,708,000	7,263,000
Victoria	13,153,000	14,110,000	15,282,000	15,736,000	11,807,000
South Australia	9,696,000	6,639,000	9,531,000	14,047,000	8,027,000
Western Australia	480,000	305,000	443,000	537,000	176,000
Tasmania	663,000	967,000	1,051,000	860,000	899,000
New Zealand	5,904,000	10,581,000	8,642,000	5,046,000	3,727,000
Queensland	215,000	405,000	477,000	426,000	562,000
Total Australasia	33,875,000	37,096,000	42,458,000	43,360,000	32,461,000
Recapitulation by continents:					
North America	689,415,000	579,650,000	453,782,000	522,850,000	538,563,000
South America	52,805,000	55,792,000	81,703,000	104,915,000	85,000,000
Europe	1,201,732,000	1,410,588,000	1,514,298,000	1,521,029,000	1,443,233,000
Asia	407,358,000	358,948,000	432,384,000	425,392,000	404,578,000
Africa	47,137,000	39,731,000	38,288,000	54,795,000	48,842,000
Australasia	33,875,000	37,096,000	42,458,000	43,360,000	32,461,000
Grand total	2,432,322,000	2,481,805,000	2,562,913,000	2,672,341,000	2,552,677,000

Acreage, production, and value of potatoes and hay in 1895.

States and Territories.	Potatoes.			Hay.		
	Acres.	Bushels.	Value.	Acres.	Tons.	Value.
Maine	62,203	10,139,089	$3,447,290	1,104,932	1,127,031	$10,909,660
New Hampshire	23,395	3,134,930	1,006,178	621,607	590,527	7,381,588
Vermont	33,338	5,134,052	1,334,854	835,476	893,959	10,950,998
Massachusetts	32,354	4,303,082	2,065,479	585,440	649,838	11,372,165
Rhode Island	7,324	1,010,712	454,820	82,216	74,817	1,290,593
Connecticut	27,052	3,462,656	1,419,689	471,106	400,440	6,447,084
New York	424,175	51,749,350	11,902,351	4,873,320	3,557,524	48,738,079
New Jersey	48,942	4,600,548	1,564,186	495,443	599,486	7,577,503
Pennsylvania	208,948	23,193,228	6,494,104	2,843,611	2,872,047	35,326,178
Delaware	5,651	327,758	124,548	55,372	68,108	828,193
Maryland	27,200	2,366,400	709,920	349,038	436,298	5,039,242
Virginia	41,525	3,031,325	1,151,904	685,488	774,601	8,853,689
North Carolina	18,494	1,461,026	803,564	167,816	273,540	2,773,696
South Carolina	4,460	401,400	293,022	144,986	144,986	1,104,793
Georgia	6,277	364,066	258,487	147,838	236,541	2,578,297
Florida	1,635	89,925	89,925	6,719	10,280	136,004
Alabama	6,859	480,130	388,905	74,987	116,980	1,194,366
Mississippi	6,262	363,196	232,445	76,119	148,432	1,439,790
Louisiana	9,301	827,789	596,008	36,897	74,532	718,488
Texas	14,338	1,276,082	995,344	457,214	676,677	4,351,033
Arkansas	21,090	1,476,300	752,913	178,663	214,396	1,987,451
Tennessee	38,177	2,443,328	977,331	396,314	550,876	5,965,987
West Virginia	33,299	2,297,631	965,005	475,246	337,425	4,295,420
Kentucky	45,444	3,908,184	1,524,192	513,865	693,718	7,589,275
Ohio	208,048	13,107,024	4,194,248	1,803,558	1,046,064	13,347,777
Michigan	236,797	23,916,497	3,826,640	1,243,048	720,968	9,437,471
Indiana	105,236	6,945,576	2,153,129	1,566,763	955,725	11,497,372
Illinois	178,561	13,749,197	4,124,759	1,998,686	1,319,133	13,521,113
Wisconsin	179,720	19,230,040	3,269,107	1,556,961	1,370,126	13,194,313
Minnesota	151,842	23,991,036	3,358,745	1,570,591	2,041,768	10,453,852
Iowa	201,230	21,340,980	4,054,786	4,270,910	4,612,583	29,751,141
Missouri	98,764	10,765,276	2,691,319	2,329,731	2,725,785	18,535,338
Kansas	109,295	7,869,240	3,305,081	3,372,007	4,181,289	13,631,002
Nebraska	119,319	7,994,373	2,398,312	1,829,752	1,811,454	6,448,776
South Dakota	61,169	4,037,154	1,049,660	1,959,200	1,547,768	5,092,157
North Dakota	40,566	5,192,448	882,716	412,237	585,377	2,037,112
Montana	5,442	288,426	138,444	311,337	292,657	3,336,290
Wyoming	2,758	275,800	154,448	236,003	254,883	1,656,740
Colorado	36,756	3,491,820	1,152,301	810,408	1,961,187	11,512,168
New Mexico	742	59,360	37,397	46,221	120,637	965,096
Arizona	422	29,118	17,471	34,408	63,655	572,895
Utah	6,191	1,064,852	362,050	179,575	459,712	2,422,682
Nevada	1,420	213,000	80,940	155,138	466,965	3,152,014
Idaho	3,888	408,240	163,296	178,832	459,598	2,872,488
Washington	16,193	2,412,757	675,572	324,472	600,273	4,051,843
Oregon	17,571	1,124,544	438,572	655,149	1,166,165	7,136,930
California	25,179	1,888,425	906,444	1,681,753	2,791,710	19,709,473
Total	2,954,952	297,237,370	78,984,901	44,206,453	47,078,541	393,185,615

Acreage, production, and value of potatoes and hay in the United States for the years 1893–1895.

Year.	Potatoes.			Hay.		
	Acres.	Bushels.	Value.	Acres.	Tons.	Value.
1893	2,605,186	183,034,203	$108,661,801	49,613,469	65,766,158	$570,882,872
1894	2,737,973	170,787,338	91,526,787	48,321,272	54,874,408	468,578,321
1895	2,954,952	297,237,370	78,984,901	44,206,453	47,078,541	393,185,615

No estimates concerning these products were made by the Department of Agriculture for the years 1889–1892.

Acreage, production, etc., of the cotton crop of 1894.

States and Territories.	Acres.	Bales.	Bales per acre.	Movement by rail and water, September 1, 1894, to April 1, 1895.	Remaining on plantations and at interior towns, April 1, 1895.	Bought by mills from September 1, 1894, to April 1, 1895.
				Bales.	*Bales.*	*Bales.*
Alabama	2,664,861	854,122	0.32	776,905	37,639	39,578
Arkansas	1,483,319	709,722	.48	669,462	39,172	1,088
Florida	201,621	48,005	.24	46,573	1,432	------
Georgia	3,610,968	1,183,924	.33	966,291	62,090	155,543
Indian Territory	233,898	104,887	.45	104,414	473	------
Kansas	168	67	.40	67	------	------
Kentucky	8,243	2,685	.33	2,685	------	------
Louisiana	1,313,296	721,591	.55	677,843	34,204	9,544
Mississippi	2,826,272	1,167,881	.41	1,109,123	46,012	12,746
Missouri	63,696	24,114	.38	23,820	294	------
North Carolina	1,296,522	454,920	.35	277,862	31,126	145,932
Oklahoma	28,992	13,001	.45	12,715	286	------
South Carolina	2,160,391	818,330	.38	571,176	34,328	212,826
Tennessee	879,954	286,630	.33	261,095	6,972	18,563
Texas	6,854,621	3,073,821	.45	2,976,048	90,697	7,076
Virginia	61,128	12,735	.21	12,580	155	------
Total	23,687,950	9,476,435	.40	8,488,659	384,880	602,896

The mill purchases shown in the last column of the foregoing table include only the cotton bought by Southern mills in the States in which they are located. To arrive at the total Southern mill purchases, there should be added 43,232 bales purchased in States other than those in which the mills are situated, and included in the movement by rail and water.

Acreage, production, and value of tobacco in 1895.

State.	Tobacco.		
	Acres.	Pounds.	Value.
Massachusetts	1,975	3,160,000	$442,400
Connecticut	6,579	9,928,000	1,638,120
New York	3,790	3,722,000	253,096
Pennsylvania	15,600	14,305,000	1,058,570
Maryland	15,233	12,796,000	742,168
Virginia	88,463	53,432,000	4,274,560
North Carolina	143,156	114,525,000	10,536,300
Alabama	2,334	1,092,000	98,280
Arkansas	3,207	2,238,000	264,084
Tennessee	53,890	43,220,000	3,025,400
West Virginia	3,849	2,527,000	283,024
Kentucky	223,574	179,753,000	9,526,909
Ohio	35,969	25,358,000	1,318,616
Indiana	13,435	8,760,000	770,880
Illinois	4,591	3,076,000	246,080
Wisconsin	3,975	3,284,000	213,517
Missouri	10,580	8,718,000	758,466
All other States	3,750	1,650,000	123,750
Total	633,950	491,544,000	35,574,220

Average farm price of various agricultural products on December 1 in each year from 1886 to 1895.

Crop.	1895.	1894.	1893.	1892.	1891.	1890.	1889.	1888.	1887.	1886.
Corn ....per bushel	$0.253	$0.457	$0.365	$0.393	$0.406	$0.506	$0.283	$0.341	$0.444	$0.366
Wheat ....do	.509	.491	.538	.624	.839	.838	.698	.926	.681	.687
Rye ....do	.440	.501	.513	.548	.774	.629	.457	.591	.544	.531
Oats ....do	.199	.324	.294	.317	.315	.424	.230	.278	.304	.298
Barley ....do	.337	.442	.411	.472	.540	.648	.427	.596	.522	.530
Buckwheat ....do	.452	.556	.583	.534	.579	.577	.518	.636	.561	.544
Irish potatoes ....do	.266	.536	.590	.673	.371	.777	.403	.404	.685	.450
Hay ....per ton	8.35	8.54	8.68	8.49	8.39	7.74	7.88	------	9.34	7.36
Cotton ....per pound	.076	.046	.070	.084	.073	.086	.083	.085	.085	.081
Leaf tobacco ....do	.069	.068	.081	------	.084	.077	.071	------	.103	.069

Estimated number of horses and mules on farms and ranches, average price per head, and total value of each kind, January, 1896.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	116,592	$53.57	$6,246,147			
New Hampshire	55,589	49.51	2,752,366			
Vermont	91,999	44.24	4,070,261			
Massachusetts	65,102	72.49	4,719,255			
Rhode Island	10,029	77.00	772,186			
Connecticut	43,913	66.55	2,922,861			
New York	654,045	47.77	31,246,088	4,674	$59.42	$277,737
New Jersey	82,437	65.47	5,397,256	7,886	84.51	666,480
Pennsylvania	607,516	47.13	28,629,629	36,509	60.72	2,216,993
Delaware	29,974	52.68	1,578,881	5,269	66.07	348,140
Maryland	134,995	44.75	6,040,939	13,213	61.02	806,321
Virginia	246,046	39.86	9,808,229	38,248	55.80	2,134,133
North Carolina	144,095	54.36	7,833,392	110,860	59.31	6,574,729
South Carolina	64,514	59.01	3,806,977	95,955	73.70	7,071,663
Georgia	109,185	52.90	5,775,859	166,040	67.50	11,207,968
Florida	35,162	50.09	1,761,225	8,357	65.09	543,916
Alabama	128,336	42.52	5,456,987	127,195	53.19	6,765,542
Mississippi	182,777	39.77	7,269,553	153,877	51.50	7,924,027
Louisiana	137,344	35.45	4,868,336	90,040	56.30	5,068,858
Texas	1,183,777	20.72	24,528,683	264,069	34.56	9,125,296
Arkansas	235,618	32.76	7,719,845	145,519	43.39	6,313,361
Tennessee	344,440	39.95	13,758,944	182,139	42.05	7,659,823
West Virginia	161,352	32.92	5,311,241	7,601	43.28	328,963
Kentucky	417,582	34.78	14,521,752	131,297	36.10	4,740,184
Ohio	771,355	37.88	29,218,761	19,475	41.18	801,960
Michigan	454,610	44.74	20,340,685	3,026	47.19	142,802
Indiana	694,445	34.18	23,732,946	50,431	37.77	1,904,802
Illinois	1,179,072	29.26	34,502,959	97,453	36.24	3,531,725
Wisconsin	442,853	42.19	18,683,229	4,925	44.04	216,880
Minnesota	488,647	38.44	18,783,990	8,991	46.99	422,526
Iowa	1,182,056	28.79	34,032,583	34,044	36.13	1,230,083
Missouri	918,415	25.09	23,039,549	231,684	29.84	6,914,427
Kansas	857,789	24.03	20,609,057	87,520	32.52	2,845,995
Nebraska	632,653	25.70	16,259,065	43,709	35.62	1,556,735
South Dakota	287,896	26.31	7,575,013	6,937	33.26	230,727
North Dakota	170,104	34.18	5,814,212	7,607	54.72	416,232
Montana	182,605	21.94	4,005,441	994	26.63	26,467
Wyoming	81,699	17.12	1,399,006	1,445	32.23	48,023
Colorado	164,645	21.98	3,618,349	8,888	45.56	404,907
New Mexico	83,862	16.68	1,398,569	3,747	34.65	129,850
Arizona	56,449	20.63	1,164,770	1,221	27.52	33,605
Utah	71,897	12.55	902,149	1,735	23.55	40,865
Nevada	53,561	18.68	1,000,260	1,604	27.99	44,903
Idaho	134,705	24.71	3,328,570	941	31.90	30,014
Washington	192,055	29.03	5,574,956	1,420	39.48	56,064
Oregon	219,115	21.11	4,625,783	6,182	27.62	170,755
California	482,818	27.16	13,114,254	59,251	35.02	2,074,789
Oklahoma	38,332	16.17	619,638	6,968	22.27	155,167
Total, 1896	15,124,057	33.07	500,140,186	2,278,946	45.29	103,204,457
Total, 1895	15,893,318	36.29	576,730,580	2,333,108	47.55	110,927,834
Decrease	769,261	3.22	76,590,394	54,162	2.26	7,723,377
Decrease (per cent)	4.8	8.9	13.3	2.3	4.8	7.0

Number and value of horses, mules, and milch cows in the United States for the years 1891–1896.

January 1—	Horses.		Mules.		Milch cows.	
	Number.	Value.	Number.	Value.	Number.	Value.
1891	14,056,750	$941,823,222	2,296,532	$178,847,370	16,019,591	$346,397,900
1892	15,498,140	1,007,593,636	2,314,699	174,882,070	16,416,351	351,378,132
1893	16,206,802	992,225,185	2,331,128	164,763,751	16,424,087	357,299,785
1894	16,081,139	769,224,799	2,352,231	146,232,811	16,487,400	358,998,661
1895	15,893,318	576,730,580	2,333,108	110,927,834	16,504,629	362,601,729
1896	15,124,057	500,140,186	2,278,946	103,204,457	16,137,586	363,955,545

Estimated number of milch cows and of oxen and other cattle on farms and ranches, average price per head, and total value of each kind, January, 1896.

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	192,077	$28.14	$5,405,047	117,802	$24.46	$2,880,939
New Hampshire	127,694	29.50	3,766,973	84,723	24.40	2,067,306
Vermont	258,471	24.82	6,415,250	143,643	21.20	3,044,576
Massachusetts	174,572	34.63	6,045,428	80,476	26.36	2,121,662
Rhode Island	24,763	38.33	949,166	11,596	23.81	276,120
Connecticut	136,206	29.90	4,072,559	69,390	25.15	1,745,494
New York	1,445,232	24.30	35,119,138	597,428	23.12	13,813,491
New Jersey	200,347	34.38	6,887,930	47,487	26.35	1,251,502
Pennsylvania	947,766	24.22	22,954,893	610,776	20.70	12,642,879
Delaware	34,174	29.00	991,046	25,482	19.99	509,258
Maryland	150,477	24.50	3,686,687	116,045	19.31	2,241,000
Virginia	265,635	18.14	4,818,619	386,675	15.88	6,138,896
North Carolina	272,046	14.40	3,917,462	363,585	10.12	3,680,396
South Carolina	129,388	16.88	2,184,069	158,450	10.11	1,601,346
Georgia	312,711	16.95	5,300,451	540,916	9.11	4,926,936
Florida	114,332	13.32	1,522,902	361,054	7.97	2,878,718
Alabama	308,439	10.91	3,365,069	523,329	6.70	3,507,352
Mississippi	293,870	13.81	4,058,345	485,695	7.49	3,636,691
Louisiana	166,889	14.10	2,353,135	312,122	8.34	2,603,311
Texas	783,936	17.89	14,024,615	5,518,644	12.60	69,520,010
Arkansas	295,827	12.87	3,807,293	516,695	8.49	4,388,084
Tennessee	330,690	15.53	5,135,616	519,124	10.58	5,493,215
West Virginia	175,029	20.54	3,595,096	296,613	15.35	4,553,985
Kentucky	303,682	20.38	6,189,029	506,997	17.33	8,786,669
Ohio	759,597	24.25	18,420,227	686,285	21.41	14,693,645
Michigan	468,523	25.16	11,788,039	398,656	17.61	7,018,495
Indiana	637,404	24.70	15,743,879	798,414	20.60	16,447,970
Illinois	1,018,443	27.46	27,966,445	1,430,976	20.42	29,214,530
Wisconsin	802,902	22.21	17,832,453	673,250	17.37	11,693,824
Minnesota	600,515	21.44	12,875,042	694,321	15.03	10,434,540
Iowa	1,202,560	25.78	31,001,997	2,336,973	21.46	50,159,389
Missouri	723,309	24.00	17,359,416	1,686,990	19.30	32,565,492
Kansas	622,892	22.12	13,778,371	1,766,245	19.20	33,903,604
Nebraska	534,197	21.92	11,709,598	1,062,469	17.86	18,980,269
South Dakota	292,874	20.41	5,977,558	399,814	16.50	6,597,768
North Dakota	156,571	21.63	3,386,631	255,502	19.81	5,061,518
Montana	42,086	27.90	1,174,199	1,153,557	17.24	19,882,720
Wyoming	18,332	24.50	449,134	751,849	16.48	12,389,717
Colorado	79,975	25.00	1,999,375	926,560	17.17	15,910,331
New Mexico	18,383	23.00	422,809	793,506	10.15	8,056,069
Arizona	15,622	25.00	390,550	636,512	10.14	6,457,164
Utah	57,271	15.20	870,519	369,374	11.51	4,253,114
Nevada	18,196	24.50	445,802	259,078	12.07	3,126,940
Idaho	28,034	20.25	567,689	395,852	14.10	5,583,492
Washington	117,381	22.08	2,591,772	381,550	15.21	5,803,002
Oregon	113,732	18.43	2,096,081	788,452	12.64	9,962,640
California	335,646	23.75	7,971,593	888,832	15.82	14,057,319
Oklahoma	28,888	19.75	570,538	155,645	15.20	2,365,031
Total, 1896	16,137,586	22.55	363,955,545	32,085,409	15.86	508,928,416
Total, 1895	16,504,629	21.97	362,601,729	34,364,216	14.06	482,999,129
Decrease	367,043	[1] .58	[1] 1,353,816	2,278,807	[1] 1.80	[1] 25,929,287
Decrease (per cent)	2.2	[1] 2.6	[1] .4	6.6	[1] 12.8	[1] 5.4

[1] Increase.

Progress of dairying in the United States.

[From the Reports of the Census.]

Year of Census.	Milch cows.		Butter, total amount made.	Cheese, total amount made.	Creameries and cheese factories.	Milk, average yield per cow.
	Total number.	Per 1,000 persons.				
			Pounds.	*Pounds.*	*Number.*	*Gallons.*
1890	16,511,950	264	1,205,508,384	256,761,883	4,712	315.4
1880	12,443,120	248	806,672,071	243,157,850	3,932	232.5
1870	8,935,332	232	514,092,683	162,927,382	[1] 1,313	205.9
1860	8,585,735	273	459,681,372	103,663,927	[2] 5	174.7
1850	6,385,094	275	313,345,306	105,535,893	[2] 8	166.5

[1] Cheese factories only.
[2] The establishments reported for 1850, 1860, and 1870 were all cheese factories. The figures for 1850 are approximately correct, but those for 1860 are known to be much too small.

Estimated number of sheep and swine on farms and ranches, average price per head, and total value of each kind, January, 1896.

States and Territories.	Sheep.			Swine.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	258,836	$2.07	$536,438	78,403	$7.60	$595,865
New Hampshire	87,111	2.12	184,849	56,400	7.76	437,523
Vermont	181,550	1.93	349,593	78,572	7.42	582,990
Massachusetts	48,395	3.30	159,703	60,726	8.44	512,647
Rhode Island	11,279	3.38	38,067	14,433	9.80	141,446
Connecticut	34,520	2.66	91,892	53,737	8.94	480,406
New York	899,179	2.38	2,137,798	645,433	6.50	4,193,897
New Jersey	45,089	4.04	182,340	163,231	7.78	1,269,448
Pennsylvania	907,672	2.16	1,957,667	1,033,104	6.26	6,464,234
Delaware	12,358	2.89	35,739	52,167	6.40	333,867
Maryland	129,884	2.68	348,375	338,659	5.32	1,800,651
Virginia	426,889	2.10	894,760	985,748	3.82	3,768,514
North Carolina	343,194	1.39	478,069	1,427,345	3.92	5,592,196
South Carolina	74,465	1.47	109,762	945,662	4.33	4,090,963
Georgia	378,769	1.37	519,368	1,954,241	3.55	6,931,302
Florida	101,777	1.85	188,573	395,254	2.16	855,013
Alabama	271,111	1.15	311,534	1,848,898	2.86	5,280,452
Mississippi	343,996	1.23	423,115	1,940,755	3.09	5,991,888
Louisiana	146,571	1.39	203,353	888,720	2.85	2,534,629
Texas	3,065,256	1.25	3,839,540	3,035,119	3.59	10,896,078
Arkansas	188,972	1.29	244,662	1,563,166	2.53	3,954,809
Tennessee	439,466	1.48	651,068	1,910,749	3.34	6,384,196
West Virginia	514,783	1.74	894,281	375,042	4.02	1,509,470
Kentucky	858,366	1.87	1,603,257	1,688,594	3.59	6,053,946
Ohio	2,754,613	1.91	5,247,538	2,456,626	4.41	10,822,911
Michigan	1,491,079	1.91	2,843,189	720,694	5.83	4,203,518
Indiana	727,509	2.30	1,669,779	1,654,772	4.72	7,802,580
Illinois	694,470	2.41	1,670,687	2,392,980	5.14	12,301,830
Wisconsin	770,350	1.94	1,498,176	902,507	6.27	5,656,011
Minnesota	435,381	1.94	844,290	560,957	5.11	2,869,295
Iowa	565,137	2.48	1,399,279	4,854,507	5.66	27,462,917
Missouri	774,738	1.91	1,475,953	3,169,411	3.90	12,363,872
Kansas	258,390	1.60	413,966	1,676,487	5.07	8,498,279
Nebraska	192,620	2.17	417,234	1,289,726	5.01	6,458,948
South Dakota	320,247	1.95	624,354	160,064	5.22	835,054
North Dakota	359,828	1.98	710,732	117,949	5.14	605,787
Montana	3,061,502	1.55	4,740,429	52,087	6.91	359,868
Wyoming	1,393,693	1.80	2,513,944	15,834	7.20	113,933
Colorado	1,319,049	1.71	2,251,881	23,419	5.72	133,957
New Mexico	2,738,030	1.00	2,732,554	31,787	5.63	178,898
Arizona	746,546	1.25	930,196	20,695	7.39	152,980
Utah	1,998,441	1.58	3,157,537	56,621	6.95	393,671
Nevada	544,077	1.71	930,372	11,590	6.26	72,553
Idaho	1,011,852	2.25	2,281,726	77,518	5.14	398,250
Washington	756,346	1.74	1,318,462	239,413	4.35	1,041,160
Oregon	2,630,949	1.36	3,590,983	252,685	3.17	801,819
California	2,962,126	1.85	5,483,784	507,461	4.03	2,045,677
Oklahoma	22,322	1.65	36,887	62,811	4.77	299,577
Total, 1896	38,298,783	1.70	65,167,735	42,842,759	4.35	186,529,745
Total, 1895	42,294,064	1.58	66,685,767	44,165,716	4.97	219,501,267
Decrease	3,995,281	[1] .12	1,518,032	1,322,957	.62	32,971,522
Decrease (per cent)	9.4	[1] 7.6	2.3	3.0	12.5	15.0

[1] Increase.

Number and value of oxen and other cattle, and also of sheep and swine, with the total value of all farm animals in the United States, 1891 to 1896.

January 1—	Oxen and other cattle.		Sheep.		Swine.		Total value of farm animals.
	Number.	Value.	Number.	Value.	Number.	Value.	
1891	36,875,648	$544,127,908	43,431,136	$108,397,447	50,625,106	$210,193,923	$2,329,787,770
1892	37,651,239	570,749,155	44,938,365	116,121,290	52,398,019	241,031,415	2,461,755,698
1893	35,954,196	547,882,204	47,273,553	125,909,264	46,094,807	295,426,492	2,483,506,681
1894	36,608,168	536,789,747	45,048,017	89,186,110	45,206,498	270,384,626	2,170,816,754
1895	34,364,216	482,999,129	42,294,064	66,685,767	44,165,716	219,501,267	1,819,446,306
1896	32,085,409	508,928,416	38,298,783	65,167,735	42,842,759	186,529,745	1,727,926,084

Prices of principal agricultural products on the farm December 1, 1891 to 1895.

States and Territories.	Corn (per bushel.)					Wheat (per bushel).					Oats (per bushel).					Barley (per bushel).					Hay (per ton).					Cotton (per pound).				
	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.	1891.	1892.	1893.	1894.	1895.
	Cts	Cts	Cts	Cts	Cts						Cts	Cts	Cts	Cts	Cts	Cts	Cts	Cts	Cts	Cts						Cts	Cts	Cts	Cts	Cts
Maine	80	67	62	72	54	$1.10	$1.02	$1.02	$0.79	$0.82	45	45	45	44	34	72	68	67	66	52	$9.30	$12.80	$12.13	$9.60	$9.68					
New Hampshire	77	65	57	76	51	1.15	1.00	.85	.80	.76	46	44	43	49	35	74	74	70	63	56	11.00	13.20	15.60	10.50	12.50					
Vermont	76	64	61	69	48	1.14	.96	.85	.67	.69	41	43	42	51	33	72	66	60	60	47	9.00	10.00	10.63	9.94	12.25					
Massachusetts	78	62	62	61	52		.97				47	48	42	43	34	75	75	90	63	65	16.00	16.60	17.33	15.50	17.50					
Rhode Island	79	63	69	75	56						47	49	43	47	39	78	82	87	72	75	16.25	17.40	19.60	16.33	17.25					
Connecticut	76	62	64	68	51	1.06	.87			.68	45	45	40	43	31	70	76				15.75	16.50	17.50	15.56	16.10					
New York	66	60	55	61	45	1.00	.85	.76	.62	.68	38	39	30	39	28	65	75	60	56	81	11.00	11.00	11.33	9.66	13.70					
New Jersey	65	58	52	54	42	1.04	.83	.70	.61	.71	40	41	35	38	29						14.40	14.25	17.43	14.09	12.64					
Pennsylvania	57	57	49	55	39	1.00	.81	.65	.56	.65	37	40	35	38	27	64	57	50	48	41	10.00	12.30	14.40	11.31	12.30					
Delaware	55	44	40	45	34	1.00	.75	.60	.55	.64	39	38	38	35	29						12.00	12.33	17.00	15.00	12.16					
Maryland	53	45	44	50	37	1.00	.74	.76	.54	.64	38	38	35	39	27			55			11.15	11.75	14.25	11.13	11.55					
Virginia	50	53	46	47	37	1.00	.76	.63	.56	.65	41	39	35	37	30	62		48			11.00	11.50	13.09	11.89	11.43	7	8.6	7.1	5	7.8
North Carolina	58	54	50	47	38	1.02	.89	.72	.65	.72	51	45	44	44	38			52			11.00	10.55	11.11	10.93	10.14	7.4	8.6	7.2	4.8	8.2
South Carolina	70	57	60	65	46	1.10	.93	.98	.87	.88	61	52	53	53	49			115			12.18	11.30	9.67	10.75	7.62	7.4	8.6	7.1	5	8.8
Georgia	69	56	56	58	41	1.10	.90	.90	.76	.82	60	52	52	51	46			115			13.50	11.80	12.06	12.38	10.90	7.4	8.5	7.3	4.5	7
Florida	80	60	68	71	47						62	55	55	61	65						15.00	14.00	19.75	16.25	13.23	7.3	8.2	7.3	4.8	11.5
Alabama	63	52	59	53	37	1.10	.93	.88	.78	.80	60	51	51	51	42						12.38	10.80	11.24	9.51	10.21	7.3	8.5	7	4.8	7.8
Mississippi	58	51	55	49	37	1.00	.90	.85	.75	.61	58	50	47	47	39						11.22	9.91	9.61	9.67	9.70	7.3	8.5	7	4.1	7.5
Louisiana	60	50	57	62	40						52	50	44	47	36						11.58	9.89	9.00	10.64	9.64	7.3	8.4	7	4.3	7.8
Texas	55	45	54	56	31	.87	.75	.58	.54	.66	47	38	42	39	26	78	65	62	55	54	8.75	8.56	9.60	7.62	6.43	7	8	6.9	4.5	7.3
Arkansas	46	47	45	47	32	.90	.80	.65	.55	.59	42	40	39	40	32						10.57	8.74	9.37	8.83	9.27	7.3	8.5	6.8	4.8	7.6
Tennessee	43	43	39	39	27	.93	.68	.57	.51	.62	40	38	31	35	27		66	55	56	50	11.30	10.40	10.76	11.27	10.83	7.3	8.5	6.5	4.5	7.3
West Virginia	52	56	55	57	40	.96	.75	.72	.60	.69	40	41	38	39	32					38	9.17	10.50	12.75	10.66	12.73					
Kentucky	40	40	43	44	27	.90	.67	.57	.50	.61	37	37	34	36	26		38	51	47	38	10.15	9.50	10.16	10.47	10.94					
Ohio	41	42	40	43	27	.92	.68	.57	.49	.60	33	35	30	31	22	60	57	47	48	41	8.20	9.17	10.05	8.46	12.76					
Michigan	48	46	45	50	32	.91	.67	.57	.52	.60	32	35	32	34	23	60	60	49	50	43	11.00	8.40	9.16	9.04	13.09					
Indiana	38	40	36	37	23	.86	.64	.53	.46	.57	32	34	28	30	20	59	52	45	45	40	7.70	7.80	9.16	7.58	12.03					
Illinois	37	37	31	39	22	.85	.63	.51	.45	.53	28	31	27	29	17	55	49	40	48	45	7.72	7.53	8.86	8.33	10.25					
Wisconsin	44	38	35	45	30	.84	.62	.54	.51	.51	28	29	27	30	18	55	50	43	45	34	9.80	7.65	7.20	7.96	9.63					
Minnesota	39	37	34	43	20	.78	.61	.51	.49	.44	27	28	26	30	14	43	42	36	41	24	5.75	4.60	4.57	5.30	5.12					
Iowa	30	32	27	45	18	.81	.60	.49	.50	.46	26	26	23	28	14	42	40	33	42	23	5.50	5.25	6.16	7.39	6.45					
Missouri	38	36	30	40	20	.80	.58	.48	.43	.51	29	30	25	29	18	37	42	40	51	48	6.20	6.75	7.04	7.82	6.80		7.8		4.6	7.4
Kansas	34	31	31	43	19	.73	.52	.42	.44	.45	27	26	27	31	17	40	35	47	49	23	3.62	4.40	4.69	5.25	3.26					
Nebraska	26	28	27	50	18	.73	.50	.40	.49	.40	23	23	22	36	14	37	33	31	43	24	3.17	4.27	4.87	7.12	3.56					
South Dakota	35	33	25	46	23	.72	.51	.44	.46	.38	25	23	25	35	17	41	35	33	35	19	4.20	3.40	3.67	4.28	3.29					
North Dakota	40	40	38	44	24	.70	.52	.43	.43	.38	26	28	28	29	16	42	33	31	36	20	4.00	4.10	3.72	3.87	3.48					
Montana		70	70	82	75	.84	.69	.60	.54	.73	48	40	37	31	44	65	66	50	40	59	8.50	8.95	7.89	7.17	11.40					
Wyoming		61	63	65	57	.82	.66	.65	.63	.64		38	40	48	39	70	68	73		28	9.00	6.40	8.00	10.00	6.50					
Colorado	53	40	51	61	41	.73	.58	.52	.65	.56	38	34	37	46	28	56	54	50	58	60	8.00	6.50	6.98	7.54	5.87					
Mew Mexico	72	72	71	75	56	.82	.80	.75	.88	.73	55	56	51	50	45	70	65	58	70	68	9.50	11.25	8.50	11.50	8.00					
Arizona		65	66	100	75	.75	.78	.65	1.00	.65						70		52	75	70		10.50	8.25	12.00	9.00					
Utah	60	58	58	58	49	.75	.62	.60	.53	.44	42	40	33	34	30	60	52	45	46	39	5.50	6.31	5.17	5.56	5.27					
Nevada						.87	.75	.73	.75	.49						75	60	60	51	50	5.00	7.00	10.00	7.25	6.75					

Idaho	----	70	71	59	62	.84	.60	.60	.46	.47	50	37	41	32	29	68	33	53	47	42	6.67	7.40	5.50	4.34	6.25	----	----	----	----	----
Washington	----	60	62	69	40	.75	.58	.48	.39	.41	41	35	35	31	28	60	45	39	32	38	10.50	9.00	9.17	7.38	6.75	----	----	----	----	----
Oregon	71	56	47	56	55	.88	.64	.55	.43	.47	41	37	37	28	27	48	46	40	33	40	8.00	8.92	8.10	5.86	6.12	----	----	----	----	----
California	71	55	50	57	53	.95	.68	.53	.57	.60	60	40	38	44	39	61	47	42	45	40	11.00	8.76	7.87	9.50	7.06	----	----	----	----	----
Oklahoma	----	----	----	----	----	----	----	----	.51	.48	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	4.6	7.5
Indian Territory	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	7.3
General average	40.6	39.3	36.5	45.7	25.3	83.9	62.4	53.8	49.1	50.9	31.5	31.7	29.4	32.4	19.9	54	47.2	41.1	44.2	33.7	8.39	8.49	8.68	8.54	8.35	7.3	8.4	6.99	4.6	7.59

Wholesale prices of principal agricultural products in leading cities of the United States.

CORN (PER BUSHEL).

Date.	Boston.		New York.		Richmond.		New Orleans.		Cincinnati.		Chicago.		Kansas City.		St. Paul.		St. Louis.		San Francisco (per cental).	
1891.	*No. 2 mixed.*		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2.*		*No. 2 mixed.*		*No. 3.*		*No. 2.*		*No. 1 white.*	
August	$0.76 to	$0.77	$0.71¼ to	$0.72	$0.72 to	$0.73		$0.72		$0.63	$0.60 to	$0.60¼		$0.51¼	$0.58 to	$0.60	$0.53¼ to	$0.54	$2.05 to	$2.11
September		.76	.74	.75	.66	.67	$0.74 to	.75	$0.64 to	.64½	.64¼	.65		.55½	.58	.59	.58¾	.59	1.85	1.87½
October	.67	.68	.61¾	.62	.67	.68	.69	.70		.57	.52½	.53½		.46¾	.48	.52		.53	1.37½	1.40
November		.69	.69	69½	.60	.61		.73	.57	.58	.54	.55	------	------	.52	.54		.48¼	1.17½	1.20
December	.72	.73	.74	.76	.53	.54	.58	.59		.52	.46¼	.47¼	------	------	.42	.45	.40¾	.42¼	1.40	1.45
1892.	*Steamer mixed*														*No. 3 yellow.*					
August	.59	.59¼	.59	.60	.57	.58	.63	.64	.53	.53½	.49⅝	.49⅞		.43½	.45	.47	.45½	.45¾	1.40	1.42½
September		.61		.58¼	.57	.58		.60	.50	.51	.48½	.48¾		.42¼	.47	.48	.44	.44¼	1.37½	1.40
October		.55½	.51⅞	.52¼	.55	.56	.59	.60	.46½	.47	.43⅜	.43⅝		.37½	.44	.45	.40⅝	.41	1.35	1.36¼
November	.52½	.53	.50⅞	.51⅜	Nominal.		.52	.53		.43	41⅝	.41½		.33	.40	.41		.38¼	1.15	1.17½
December	.54	.55	.51½	.51⅝	.49	.50		.51		.43	.42	.42¼		.38½	.39	.40	.38¼	.38½	1.12½	1.15
1893.																				
August		.49	.46⅛	.46¼	.47	.48		.51		.41	.38	.38⅜		.28¼	.35	.36	.34½	.34¼	1.00	1.02½
September		.50	.45	.45¼		.47		.50		.41½	.37½	.37¼		.30¼	.35	.36	.34	.34¼	.90	.95
October		.51		.49	.50	.51		.53	.42½	.43	.39¾	.40¼		.34	.37	.38	.35⅝	.36	.92½	.96
November		.50	.45½	.46¼		.47	.51	.52		.39	.38¼	.38½	$0.31½ to	.32	.37	.38		.35¼	.85	.87½
December		.46½	.44¾	.45½	.43	.44		.49		.40	.34⅞	.35½	.30	.30¼	.33	.34		.34	.90	.92½
1894.																				
August		.57	.53½	.54	.52	.53	.56	.57		.50	.46½	.46¼	.41	.42	.45½	.46½	.44½	.45½	1.35	1.37½
September		.65½	------	------	.61	.62		.70		.56	.53⅞	.57½		.52½	.57	.58	.53½	.54	1.25	1.27½
October		.60	.55½	.55¼		.59		.71	.54½	.54¼	.49⅜	.49⅝		.46	.54	.54½	.49¾	.50¼	1.30	1.32½
November		.61¼		.60		.55		.57		.52½	.52	.52¼	.42½	.43	.54½	.55	.48⅝	.48½	1.30	1.32½
December		.54		.58	.43	.44	.53	.54		.46	.46¾	.47	.41½	.41¾	.51	.52	.45½	.45½	1.27½	1.30
1895.															*No. 3.*					
August		.54	.48½	.49¼		.49	.53	.54		.43½	.43	.44¼	------	------	.42½	.43		.39	1.07½	1.10
September	.45	.46	.40⅜	.41¼		.41		.45	.37	.37½	.35¾	.36⅜		.30	.35½	.36½	.33	.33½	------	------
October	.41½	.42	.37	.37⅜		.39		.38		.33½	.30⅝	.31¼	.26½	.26¾	.31½	.32		.26¼	------	------
November	.39	.39½		.37½		.36		.39		.32	.29⅝	.29⅞		.23½	.30	.30½		.26½	------	------
December		.38		.35		.36		.37		.30	.26¼	.26⅝	.22¼	.23	.24	.24½		.24½	------	------

Wholesale prices of principal agricultural products in leading cities of the United States—Continued.

WHEAT (PER BUSHEL).

Date.	Boston.	New York.		Richmond.		New Orleans.	Cincinnati.		Chicago.		Kansas City.		St. Paul.		St. Louis.		San Francisco (per cental).	
1891.		*No. 2 red winter.*		*No. 2 red.*			*No. 2 red winter.*		*No. 2 red winter.*		*No. 2 hard.*		*No. 2 northern.*		*No. 2 red winter.*		*No. 1 white.*	
August	....	$0.99 to	$0.99¼		$0.97	....	$0.87 to	$0.87½	$0.87½ to	$0.88		$0.78½	$0.92 to	$0.93	$0.84¼ to	$0.84½	$1.50 to	$1.56¼
September	....	1.07¼	1.08¼	$1.05 to	1.06	....	.98½	.99	.98½	.99½	$0.87¼ to	.87½	.88	.91	.97¼	.97½	1.70	1.71¼
October	....	1.03¾	1.04¼	1.03	1.04	....	.97	.97½	.95	.95¼	....		.87	.88	.93¾	.93¾	1.67½	1.68¾
November	....	1.04	1.05¼	1.02	1.03	....		.94	.94	.94¼	....		.86	.87		.92⅝	1.72½	1.73¾
December	....	1.05¾	1.06⅝		1.04	....		.96	.90⅛	.91¼	....		.82	.84	.94⅛	.94¼	1.81¼	1.82¾
1892.		*No. 2 red.*					*No. 2 red.*											
August	....	.83¾	.84¼	.82¼	.83	....		.75	.77½	.77⅞		.65	.73	.75	.73¼	.73½	1.37½	1.38¾
September	....	.78⅝	.79¼	.77	.78	....		.73		.73¾		.65	.68	.70	.68¾	.69	1.28¾	1.30
October	....	.79¼	.79¼	.78	.79	....	.72½	.73	.72¾	.73¼		.61½	.66	.68		.69	1.28¾	1.30
November	....	.74⅝	.75⅝	.72	.73	....		.66	.70¾	.71		.60	.63	.65	.65⅛	.65⅞	1.27½	1.30
December	....	.76¾	.78⅛	.76	.77	....		.70	.71¼	.71⅞		.65	.62	.65		.68¾	1.26¼	1.27½
1893.																		
August	....	.66¾	.68½	.64	.64½	....	.52¼	.53	.57⅞	.59¼		.46½	.54	.55	.54⅛	.54½	1.07½	1.10
September	....	.69	.69¼	.63½	.64	....	.57	.58	.62¾	.63¼		.51½	.56	.57		.59¼	1.01½	1.02½
October	....	.72⅛	.72¼	.70	.71	....		.64	.66	.66⅝		.55	.58	.59		.62⅜	1.04	1.05
November	....	.67¾	.68¼		.69	....		.59½	.62⅛	.62⅞	.50½	.51	.58	.59		.58¼	1.02¼	1.05
December	....	.68⅛	.69¼		.64	....	.59	.60	.63	.63½	.53	.53⅛	.57	.58		.59⅛	1.02½	1.03¾
1894.																		
August	....	.55¼	.56½		.54	....	.48	.48½	.52	.53	.44	.45	.56½	.57		.47¾	.87½	.90
September	....	.57⅞	.58¾	.57	.57½	....		.51	.53	.53⅞	.53	.53¼	.52	.54½	.49⅜	.50⅞	.85	.86¼
October	....	.56	.57¼		.55	....	.51⅜	.51½	.51⅜	.52		.54¼	.53	.54	.48½	.48¾	.77¼	.78⅜
November	....	.56½	.57	.56	.56½	....		.51	.52½	.53½	.47½	.48	.54½	.55	.48½	.48⅜	.85	.86½
December	....	.60⅝	.61½		.60	....		.53	.55½	.56	.53	.54	.57½	.58½	.52¼	.52⅝	.92¼	.93½
1895.																		
August	....	.75	.75½		.72	....		.71	.67⅞	.69¼		.68½	.67	.67½		.68¼	.96	.97½
September	....	.65⅛	.67		.67	....		.64	.60	.61⅞		.60	.55¼	.56	.61¾	.61⅝	....	
October	....	.66⅝	.69⅞		.72	....		.70	.61¼	.61½		.64	.55	.55¼		.64½	....	
November	....	.70½	.71⅜	.72	.73	....		.66¼	.58⅝	.62⅝		.58	.53½	.54		.61⅝	....	
December	....	.70¾	.71¼		.71	....		.67½	.59¼	.61½	.57½	.58	.53	.54		.63	....	

OATS (PER BUSHEL).

	No. 2 white.		No. 2 mixed.		No. 2 mixed.		No. 2.		No. 2 mixed.		No. 2.		No. 2 mixed.		No. 2 white.		No. 2.		No. 1.	
1891.																				
August	$0.48 to	$0.50		$0.37	$0.42 to	$0.43		$0.45	$0.31½ to	$0.32½	$0.27¼ to	$0.28		$0.26¾	$0.37 to	$0.38	$0.27½ to	$0.28		$1.47½
September		.41	$0.35¼ to	.35½	.37	.38		.41	.31½	.32	.28½	.28½		.27½	.27	.28		.28	$1.32 to	1.35
October	.37	.37½	.33	.33½	.33	.34		.37½	.30½	.31½	.26¾	.27	----	----	.27	.28	.27¼	.27½	1.37½	1.40
November	.39½	.40	.36¼	.37½	.37	.38		.38	.31¼	.31½		.30½	----	----	.28	.29		.28½		1.37½
December		.43½	.40¼	.40¾	.38	.39		.42	.34½	.35	.32	.32¼	----	----	.30½	.31		.32	1.40	1.41½
1892.																				
August	.41	.41½	.35½	.36	.38	.38½		.40	.33	.33½	.30½	.30⅝		.26	.31½	.32		.30	1.37½	1.40
September		.42	.37	.38	.37	.38	$0.40 to	.41	.34	.34¼	.33¾	.33¾		.27½	.32	.32½		.29⅛	1.32½	1.35
October	.40½	.41		.36	.37	.38		.40	.33¼	.33½	.31	.31¼		.26½	.32	.33	.29⅛	.29¾	1.25	1.27½
November		.41½		.35¾	.35½	.36		.38	.32	.32½		.30	----	----	.29½	.30¾	.28⅝	.29	1.25	1.27½
December		.43		.36¼	.39	.40		.41	.35½	.36		.31½		.32	.31½	.32		.31	1.27½	1.30
1893.																				
August		.39	.35½	.36	.32	.33	.38	.38½	.21	.22	.23	.23⅝		.23	.29½	.30½		.22½	1.05	1.10
September	.35	.35½	.30⅛	.30¼	.31	.32		.34	.26½	.26½	.23¾	.24	$0.27 to	.29	.26½	.27½	.23¼	.23½	1.07½	1.10
October	.37	.37½	.34¼	.34¾	.34	.35		.36	.31	.32	.27¾	.28		.28½	.26½	.27½		.27¼	1.10	1.12½
November		.37¼	.34½	.34¾	.34¼	.35		.38		.29½		.28	.26¼	.27½	.27¼	.28		.26¾	1.05	1.10
December		.38	.34⅜	.34½	.34¼	.35		.38	.31⅛	.32		.28¼	.27	.27½	.27	.27¼		.27¾	1.05	1.07½
1894.																				
August	.44	.45		.40		.34½	.38	.39	.30½	.31	.28¾	.29	.27½	.28	----	----		.28¾	1.12½	1.15
September	.38	.38½	.33⅝	.34	.34	.34½	.38½	.39		.31	.29½	.30¼		.31	.32	.32½		.30½	1.02½	1.05
October	.37	.37½	.32½	.32¾	.33	.34		.38		.31½	.28½	.28½	.28½	.29½	.31¼	.32	.28⅝	.29½	1.00	1.02½
November	.37½	.38	.32½	.32¾	.32½	.33		.38		.30½	.28¾	.29	.29	.30	.30½	.31		.29½	.95	.97½
December		.40	.33⅝	.33½	.34	.35	.38	.38½	.31½	.32½	.29¼	.29½	.30½	.31	.31	.31½		.30	.95	.97½
1895.																			*No. 1 feed.*	
August	.33	.33½		.28	.28½	.29		.32	.25	.27	.22¼	.22¾		.19		.25		.24	.87½	.90
September	.27½	.28		.24	.24	.24½		.28	.21½	.22	.19	.20¼		.17½		.25½	----	----	----	----
October	.27½	.28	.24	.24¼	.24½	.25	.27½	.28	.21	.21½	.18½	.18½	.18	.19	----	----	----	----	----	----
November	.26	.27		.24	.23	.23½		.27	.20	.20¾		.18	.15	.16	----	----		.17⅝	----	----
December		.25½	.22¾	.22½	.23	.23½		.26	.21¼	.21½		.17¼		.18¼	----	----		.18	----	----

Wholesale prices of principal agricultural products in leading cities of the United States—Continued.

BARLEY (PER BUSHEL).

Date.	Boston.	New York.	Richmond.	New Orleans.	Cincinnati.	Chicago.	Kansas City.	St. Paul.	St. Louis.	San Francisco (per cental).
1891.	*Two-rowed State.*	*Two-rowed State.*			*No. 2 spring.*	*Fair to choice.*		*No. 2.*	*Prime.*	*No. 1 Chevalier.*
August					$0.75 to $0.78	$0.55 to $0.60		Nominal.		$1.65
September					.70 .72	.60 .68				1.37½
October					.68 .70	.40 .56		$0.55 to $0.57	$0.50 to $0.60	1.35
November					.68 .72	.53 .60		.50 .55	.50	1.35
December	$0.70 to $0.75	$0.64 to $0.66			.68 .75	.48 .55		.50 .55	.55 .60	$1.40 to 1.45
1892.									*Choice.*	
August					.64 .68	.45 .63				
September					.65	.48 .65		Nominal.		
October		.65			.65 .68	.58 .68		.48 .50	.65	1.15¼ 1.17½
November		.63 .68			.65 .67	.48 .55		.48 .50	.60	1.12½ 1.15
December		.65 .68			.65 .67	.50 .58		.50 .55	.62 .63	1.12 1.15
1893.										
August					.60 .65	.30 .35		.50 .55		
								Sample.		
September					.50 .52	.45 .52		.30 .45		1.17½ 1.20
October		.55 .60			.56 .58	.46 .58		.35 .48	.55 .58	1.15 1.17½
November		.60 .65			.58 .60	.40 .54		.35 .48	.57	1.15 1.17½
December	.60 .65	.63 .64			.58 .60	.46 .52		.35 .48	.57	1.15 1.17½
1894.	*Six-rowed western.*	*No. 2 Milwaukee.*						*No. 2 round.*		
August					.57 .60					1.25 1.27½
September	.68 .73					.55 .57½		.45 .50	.60	1.25 1.27½
October	.68 .73	.61 .62			.62 .63	.52 .54½		.45 .50	.55 .57	1.25 1.27½
November	.65 .70	.61 .62			.60 .62	.53 .56		.45 .50	.55 .56	
December	Nominal.	.63 .64			.60 .62	.52 .54½		.46 .50	.55	
1895.	*Western.*					*No. 3.*		*No. 3.*	*Choice.*	
August	Nominal.				.60 .62	.37		.40 .45		1.07 1.10
September	Nominal.					.36 .42		.32 .33		
October	.45 .55					.25 .37		.32 .34	.40	
November	.45 .55				.40 .45	.28 .40		.32 .35	.35 .37	
December	.45 .50				.39 .44	.28 .40		.28 .30	.34 .36	

HAY (PER TON).

1891.	*Fair to good.*		*Prime timothy (per cwt.).*		*No. 1 timothy.*		*Choice.*		*No. 1 timothy.*		*No. 1 timothy.*			*Wild.*		*Timothy (fancy).*	*No. 1 barley.*	
August	$14.00 to	$15.00		$0.85	$14.50 to	$15.00		$18.00	$12.00 to	$12.50	$10.50 to	$11.50	....	$6.00 to	$8.00	$15.50	$10.50 to	$11.50
September ...	14.00	16.00	$0.85 to	.90	13.00	13.50	$15.50 to	16.00	11.00	11.50	10.50	11.50	....	7.00	9.00	12.50	10.50	11.50
October	15.00	16.00	.80	.90	13.00	13.50	15.50	16.00	9.50	10.00	10.50	11.00	....	6.50	8.00	12.00	10.50	11.50
November ...	15.00	16.00	.75	.85	13.00	13.50		15.50	10.50	11.00	11.00	11.50	....	7.00	9.50	11.00	11.50	12.50
December ...	14.00	15.00	.80	.85	13.50	14.00	18.00	19.00	10.50	11.00	14.00	15.00	....	9.00	10.50	13.00	12.00	12.50
1892.			*Per ton.*											*Timothy.*				
August	17.00	18.00		19.00		15.00	16.50	17.50	11.50	12.00	12.00	12.50	....	9.00	10.00	13.00	9.00	10.00
September ...	17.00	18.00		17.00	15.00	15.25	16.50	17.50	10.00	10.50	10.50	11.50	....	9.00	10.00	12.00	7.50	8.50
October	16.50	17 00	17.00	18.00	14.00	14.50	16.50	17.50	11.00	11.50	10.50	11.00	....	9.00	10.00	13.00		7.50
November ...	16.00	17.00		17.00	13.50	14.00	15.50	16.00	10.00	10.50	10.50	11.00	....	8.00	9.50	11.50	8.00	9.00
December ...	16 00	17.00		18.00	15.50	16.00	15.50	16.00	10.50	11.00	11.00	12.00	....	8.00	9.50	12.50	8.00	9.00
1893.																		
August	17.00	18.00		20.00	17.00	17.50	18.00	18.50		13.50	9.50	10.50	....	6 00	8.00	15.00	7.00	9.00
September ...	17.00	18.00	17.00	18.00	15.00	15.50	16.50	17.50	12.00	13.00	10.00	10.50	....	7.50	9.00	11.50	8.50	9.00
October	16.00	17.00	17.00	18.00	15.00	15.50	16.00	16.50		12.50	10.00	11.00	....	7.00	8.50	12.50	8.50	9.00
November ...	15.00	16.00	17.00	18.00	14.50	15.50	17.00	18.00	11.50	12.00	10.50	11.00	....	7.50	8.50	12.00	10.00	11.00
December ...	15.00	16.50		17.00	14.00	14.50	16.50	17.00	11.00	12.00	10.00	10.50	....	7.50	8.50	12.50	10.00	11.00
1894.																		
August	15.00	15.50		18.00	13.00	13.50		17.00	11.00	11.50	11.00	12.00	....	....	....	12.00	9.00	10.00
September ...	15.00	15.50	15.00	16.00	13.50	14.00	15.50	16.50	10.00	10.50	9.50	10.00	....	9.00	10.00	12.00	8.00	9.00
October	13.00	13.50		15.00	12.00	12.50	16.00	16.50	9.50	10.00	10.00	10.50	....	9.50	10.50	11.50	9.00	10.00
November ...	13.00	13.50		15.00	12.50	13.00	16.00	16.50	9.00	9.50	10.00	10.50	....	9.50	10.50	12.00	9.00	10.00
December ...	13.00	13.50		15.00	12.50	13.00	16.00	17.00	10.00	10.50	10.00	11.00	....	10.00	11.00	12.00	9.00	10.00
1895.														*Wild.*				
August	16.00	17.00		21.00	16.00	17.00	20.00	21.00	16.50	17.00	12.00	13.00	....	7.00	8.50	16.00	6.00	7.00
September ...	16.00	17.00		19.00	14.00	16.00	20.00	21.00	13.50	14.00	11.50	12.50	....	6.00	8.00	14.00	....	....
October	16.00	17.00		17.00	15.50	16.50	19.00	20.00	13.50	14.00	11.50	12.50	....	7.00	8.50	13.00	....	....
November ...	16.00	17.00		18.00	16.50	17.00	19 00	20.00	13.75	14.75	11.50	12.00	....	7.50	8.75	13.00	....	....
December ...	17.00	18.00		18.00	16.50	17.00		22.00	14.00	14.75	12.00	13.00	....	6.50	8.25	15.00	....	....

Wholesale prices of principal agricultural products in leading cities of the United States—Continued.

COTTON (PER POUND).

Date.	Mobile.	New York.	Savannah.	New Orleans.	Cincinnati.	Memphis.	Charleston.	Norfolk.	St. Louis.	Vicksburg.
	Middling	*Middling.*	*Middling*	*Middling.*	*Middling.*	*Middling.*	*Middling.*	*Middling.*	*Middling.*	*Middling.*
1891.										
August	$0.07 3/4	$0.08	$0.07 1/2	$0.07 3/4	$0.08 1/4	$0.07 3/4	$0.07 3/4	$0.07 1/2	$0.07 13/16	$0.07 11/16
September	.07 1/2	.08 7/16	.07 3/4	.08	.08 1/4	.08	$0.07 3/4 to .07 11/16	.08	.08	.07 13/16
October	.08 1/4	.08 11/16	.07 13/16	.08 3/8	.08 1/4	.08 7/16	.08	.08 1/8	.08 7/16	.08 5/16
November	.07 3/4	.08 5/16	.07 9/16	.07 3/4	.08 1/4	.07 13/16	.07 3/4	.07 3/4	.08	.07 13/16
December	.07 5/16	.08 1/16	.07 1/8	.07 1/2	.07 1/2	.07 9/16	.07 1/4	.07 3/8	.07 9/16	.07 3/8
1892.										
August	.07 3/16	.07 1/2	.07 3/16	.07 3/16	.07 3/4	.07 1/4	.07 1/2	.07 3/16	.07 3/16	.06 1/2
September	.07	.07 1/2	.06 3/4	.07	.07 3/4	.07	.06 3/4	.07	.07	.06 3/4
October	.07 5/16	.07 11/16	.07 1/4	.07 7/16	.07 3/4	.07 7/16	.07 1/4	.07 7/16	.07 1/2	.07 3/16
November	.07 9/16	.08 5/16	.07 1/2	.07 11/16	.08	.07 11/16	.07 3/4 .07 11/16	.07 1/2	.07 1/4	.07 7/16
December	.09 1/2	.09 3/4	.09 1/4	.09 9/16	.10	.09 7/8	.09 5/8	.09 5/8	.10	.09 5/16
1893.										
August	.07 5/8	.08	.07 5/8	.07 3/4	.08 1/4	.07 3/4	.07 3/4	.07 3/4	.07 9/16	.07 1/2
September	.07 1/2	.07 13/16	.07 1/16	.07 5/16	.07 1/2	.07 5/16	.06 7/8	.07 1/4	.07 1/4	.07 3/16
October	.07 1/2	.08 1/16	.07 7/16	.07 3/4	.08 1/4	.07 11/16	.07 9/16 .07 3/4	.07 1/2	.07 13/16	.07 5/8
November	.07 1/2	.08 3/16	.07 1/2	.07 5/8	.08	.07 3/4	.07 3/4	.07 1/4	.07 11/16	.07 1/2
December	.07 1/2	.08 1/16	.07 7/16	.07 9/16	.07 7/8	.07 3/8	.07 1/2	.07 9/16	.07 9/16	.07 7/16
1894.										
August	.06 9/16	.06 15/16	.06 5/8	.06 5/8	.07 1/4	.06 3/4	.06 1/2	.06 3/4	.06 7/8	.06 1/2
September	.06 7/16	.06 7/8	.06 5/16	.06 7/16	.07	.06 3/8	.06 1/4	.06 11/16	.06 5/8	.06 3/16
October	.05 11/16	.06 1/4	.05 9/16	.05 [illegible]	.06 1/4	.05 5/8	.05 1/2 .05 3/4	.05 3/4	.05 3/4	.05 5/16
November	.05 1/16	.05 3/4	.05 3/16	.05 3/16	.05 1/2	.05 3/16	.05 1/2	.05 1/4	.05 1/4	.04 15/16
December	.05 1/4	.05 13/16	.05 3/16	.05 5/16	.05 5/8	.05 5/16	.05 1/2	.05 1/4	.05 3/8	.05 1/16
1895.										
August	.06 5/8	.07 1/2	.06 11/16	.06 9/16	.07	.06 7/8	.06 7/8	.07	.06 11/16	.06 5/8
September	.07 5/8	.08 1/4	.07 1/2	.07 9/16	.07 1/2	.07 11/16	.07 3/4	.07 3/8	.07 5/8	.07 5/16
October	.08 5/8	.09 1/16	.08 1/2	.08 3/4	.08 3/4	.08 3/4	.08 3/8 .08 7/16	.08 5/8	.08 3/4	.08 1/2
November	----------	.09	.08 7/16	.08 5/8	.09	.08 3/4	.08 3/8	----------	.08 5/8	.08 5/8
December	----------	.08 9/16	.08 1/2	.08 3/16	.08 3/8	.08 1/4	.08 1/4	----------	.08 5/16	.08 3/16

EXPORTS OF THE PRODUCTS OF DOMESTIC AGRICULTURE FOR THE YEARS ENDING JUNE 30, 1891 TO 1895.

Article.	1891.		1892.		1893.		1894.		1895.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animals, living:										
Cattle ....number..	374,679	$30,445,249	394,607	$35,099,095	287,094	$26,032,428	359,278	$33,461,922	331,722	$30,603,796
Hogs ....do....	95,654	1,146,630	31,963	364,081	27,375	397,162	1,553	14,753	7,130	72,424
Horses ....do....	3,110	784,908	3,226	611,188	2,967	718,607	5,246	1,108,995	13,964	2,209,298
Mules ....do....	2,184	278,658	1,965	238,591	1,634	210,278	2,063	240,961	2,515	186,452
Sheep ....do....	60,947	261,109	46,960	161,105	37,260	126,394	132,370	832,763	405,748	2,630,686
All other, and fowls........	....	18,532	....	24,161	....	43,116	....	53,247	....	51,389
Animal matter:										
Bones, hoofs, horns and horn tips, strips, and waste........	....	335,710	....	218,639	....	319,848	....	260,675	....	288,084
Casings for sausages	....	841,075	....	878,675	....	1,409,280	....	1,280,514	....	1,581,891
Eggs ....dozen..	363,116	64,259	183,063	32,374	143,489	33,207	163,061	27,497	151,007	25,317
Glue........pounds..	986,552	110,292	580,815	66,403	736,446	74,722	909,052	101,372	1,178,328	114,493
Grease, grease scraps, and all soap stock	....	2,038,886	....	1,298,598	....	1,067,723	....	1,380,299	....	904,071
Hair, and manufactures of........	....	394,544	....	370,169	....	459,648	....	353,729	....	505,029
Hides and skins other than furs.lbs..	....	1,333,055	....	1,223,895	....	1,497,003	....	3,972,494	36,002,859	2,310,323
Honey	....	83,325	....	78,048	....	15,115	....	127,282	....	118,873
Oils—										
Lard ....gallons..	1,092,448	502,986	901,575	496,601	486,812	336,613	681,081	449,571	553,421	304,093
Other animal........do....	512,253	317,594	278,954	144,119	212,266	106,275	270,835	149,801	144,556	75,585
Meat products—										
Beef products—										
Beef, canned........pounds..	109,585,727	9,068,906	87,028,084	7,876,454	79,089,493	7,222,824	55,974,910	5,120,851	64,102,263	5,720,983
Beef, fresh ....do....	194,045,638	15,322,054	220,554,617	18,053,732	206,294,724	17,754,041	193,891,824	16,700,163	191,338,487	16,832,800
Beef, salted or pickled..do....	90,286,979	5,048,788	70,204,736	3,987,829	58,423,963	3,185,321	62,682,667	3,572,054	62,473,325	3,558,230
Beef, other cured ....do....	1,621,833	147,518	953,712	92,524	898,920	87,776	1,218,334	100,631	821,673	73,569
Tallow ....do....	111,689,251	5,501,049	89,780,010	4,425,630	61,819,153	3,129,059	54,661,524	2,766,164	25,864,300	1,293,059
Mutton ....do....	199,395	18,959	101,463	9,022	108,214	9,175	2,197,900	174,404	591,449	47,832
Oleomargarine—										
Imitation butter........do....	1,986,743	255,024	1,610,837	195,587	3,479,322	416,386	3,898,950	475,008	10,100,897	992,468
The oil........do....	80,231,035	7,859,130	91,581,703	9,011,889	113,939,363	11,207,250	123,295,895	11,942,842	78,098,878	7,107,014
Pork products—										
Bacon ....do....	514,675,557	37,404,989	507,919,830	39,334,933	391,758,175	35,781,470	416,657,577	38,338,843	452,549,976	37,776,293
Hams........do....	84,410,108	8,245,685	76,856,559	7,757,717	82,178,154	9,933,096	86,970,571	9,845,062	105,494,123	10,960,567
Pork, fresh........do....	818,875	56,358	377,746	30,246	912,644	79,317	1,108,647	92,095	818,581	60,660
Pork, pickled........do....	81,317,364	4,787,343	80,336,481	4,792,049	52,459,722	4,116,946	63,575,881	5,067,773	58,266,893	4,138,400
Lard........do....	498,343,927	34,414,323	460,045,776	33,201,621	365,693,501	34,643,993	447,566,867	40,089,809	474,895,274	36,821,508
Poultry and game........	....	15,808	....	13,828	....	17,978	....	18,633	....	17,898
All other meat products........	....	1,007,757	....	1,220,205	....	1,245,466	....	1,386,089	....	1,600,231
Dairy products—										
Butter ....pounds..	15,187,114	2,197,106	15,047,246	2,445,878	8,920,107	1,672,690	11,812,092	2,077,608	5,598,812	915,533
Cheese ....do....	82,133,876	7,405,376	82,100,221	7,677,657	81,350,923	7,624,648	73,852,134	7,180,331	60,448,421	5,497,539
Milk........	....	261,298	....	230,358	....	274,155	....	322,288	....	219,785

Exports of the products of domestic agriculture for the years ending June 30, 1891 to 1895—Continued.

Article.	1891.		1892.		1893.		1894.		1895.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animal matter—Continued.										
Wax, bees' ....pounds..	120,548	$30,027	127,470	$31,898	77,434	$22,048	469,763	$118,093	309,212	$90,875
Wool, raw ....do....	291,922	39,423	202,456	30,664	91,858	14,808	520,247	90,676	4,279,109	484,463
Total value of animals and animal matter	....	178,104,333	....	181,731,463	....	171,285,866	....	189,295,287	....	176,191,521
Bread and breadstuffs:										
Barley ....bushels..	973,062	669,203	2,800,075	1,751,445	3,035,267	1,468,843	5,219,405	2,379,714	1,563,754	767,228
Bread and biscuits ....pounds..	15,541,655	838,848	14,449,625	775,596	14,583,967	752,353	15,185,175	723,873	14,206,314	634,600
Corn ....bushels..	30,768,213	17,652,687	75,451,849	41,590,460	46,037,274	24,587,511	65,324,841	30,211,154	27,691,137	14,650,767
Corn meal....barrels..	318,329	946,977	287,609	919,961	271,155	793,081	291,172	770,526	223,567	648,844
Oats....bushels..	953,010	405,708	9,425,078	3,842,559	2,380,643	951,920	5,750,266	2,027,934	569,977	200,793
Oatmeal ....pounds..	7,736,873	221,316	20,908,190	555,957	5,762,701	160,660	9,719,337	238,528	20,499,253	566,321
Rye ....bushels..	332,739	212,161	12,041,316	11,432,160	1,477,058	1,002,796	230,822	126,532	9,437	5,340
Rye flour ....barrels..	4,254	18,185	4,552	22,461	2,811	10,290	3,055	9,273	3,768	12,062
Wheat ....bushels..	55,131,948	51,420,272	157,280,351	161,399,132	117,121,109	93,534,970	88,415,230	59,407,041	76,102,704	43,805,663
Wheat flour....barrels..	11,344,304	54,705,616	15,196,769	75,362,283	16,620,339	75,494,347	16,859,533	69,271,770	15,268,892	51,651,928
All other breadstuffs, and preparations of, used as food....	....	1,030,683	....	1,711,103	....	1,555,883	....	1,610,884	....	1,661,234
Total value of bread and breadstuffs....	....	128,121,656	....	299,363,117	....	200,312,654	....	166,777,229	....	114,604,780
Cotton and cotton-seed oil:										
Cotton—										
Sea island....pounds..	14,588,092	3,062,968	9,074,686	1,591,464	7,983,415	1,758,756	14,255,439	2,904,905	15,261,322	2,782,639
Other manufactured ....do....	2,892,770,703	287,649,930	2,926,145,125	256,869,777	2,204,131,711	187,012,689	2,669,026,886	207,964,384	3,502,171,787	202,118,351
Cotton-seed oil....gallons..	11,003,160	3,975,305	13,859,278	4,982,285	9,462,074	3,927,556	14,958,309	6,008,405	21,187,728	6,813,313
Total value of cotton and cotton-seed oil....	....	294,688,203	....	263,443,526	....	192,699,001	....	216,877,694	....	211,714,303
Miscellaneous:										
Broom corn....	....	172,191	....	218,133	....	163,105	....	210,742	....	169,503
Fruits and nuts—										
Apples, dried ....pounds..	6,973,168	409,605	26,042,063	1,288,102	7,966,819	482,085	2,846,645	168,054	7,085,946	461,214
Apples, green or ripe....barrels..	135,207	476,897	938,743	2,407,956	408,014	1,097,967	78,580	242,617	818,711	1,954,318
Fruits, preserved—										
Canned	....	703,880	....	1,558,820	....	1,137,660	....	660,723	....	871,465
Other	....	93,996	....	214,738	....	224,381	....	211,215	....	47,420
All other, green, ripe, or dried	....	699,798	....	1,095,845	....	881,804	....	1,016,397	....	1,522,100
Nuts	....	50,617	....	60,684	....	94,902	....	125,233	....	115,274

Hay ....tons	28,066	470,228	35,201	582,838	33,064	519,640	54,446	890,654	47,117	699,029
Hops ....pounds	8,736,080	2,327,474	12,604,686	2,420,502	11,367,030	2,695,867	17,472,975	3,844,232	17,523,388	1,872,597
Oil cake and oil-cake meal ......do	633,344,851	7,452,094	826,398,719	9,713,204	802,416,067	9,688,773	744,603,229	8,807,256	733,652,495	7,165,587
Oils—										
Linseed ....gallons	76,789	48,267	112,386	54,020	103,936	54,356	92,861	48,550	62,718	37,363
Other vegetable		93,429		73,731		236,101		129,041		106,022
Rice ....pounds	540,620	33,012			756,992	25,126	763,425	19,884	124,296	4,687
Seeds—										
Clover ....do	20,773,884	1,575,039	19,532,411	1,636,671	8,189,553	988,029	45,418,663	4,540,851	22,900,672	2,124,997
Cotton ....do	10,108,014	85,315	12,149,261	86,549	4,519,327	35,809	5,419,056	41,866	11,051,812	86,695
Flaxseed, or linseed .....bushels	144,848	184,564	3,613,817	3,915,547	1,837,370	2,195,374	2,047,836	2,426,284	1,224	1,433
Timothy ....pounds	8,757,788	370,151	10,318,074	381,651	7,077,131	504,937	10,155,867	449,207	4,939,237	277,160
All other		285,830		231,864		269,580		484,013		358;860
Sugar and molasses:										
Molasses and sirup ......gallons	4,495,475	768,306	9,343,214	1,057,216	8,373,286	992,471	9,385,359	1,038,680	9,148,711	850,400
Sugar, brown ....do	204,854	11,235	245,783	8,682	359,455	13,175	690,080	25,931	695,486	22,052
Glucose, or grape sugar ....do	58,149,427	1,394,131	96,486,953	2,272,779	101,546,814	2,204,216	124,796,288	2,328,707	133,808,329	2,567,784
Tobacco—										
Leaf ....pounds	236,969,589	20,710,911	240,716,150	20,303,245	248,367,258	22,292,704	268,791,312	22,939,356	293,805,855	25,622,776
Stems and trimming ....do	12,263,016	322,848	14,715,927	366,800	17,715,825	599,195	21,893,680	1,145,878	7,186,075	176,192
Vegetables—										
Onions ....bushels	57,182	79,993	59,842	58,121	57,610	60,878	68,865	69,823	53,335	46,703
Peas and beans ....do	251,063	473,006	637,972	945,767	389,913	745,636	326,748	576,657	242,680	429,002
Potatoes ....do	341,189	316,482	557,022	361,378	845,720	700,032	803,111	651,877	572,957	418,221
Canned		286,321		373,068		242,284		255,857		441,388
All other, including pickles and sauces		180,173		159,811		149,167		190,248		208,144
Wine—										
In bottles ....dozen	11,409	52,392	15,054	67,686	11,128	51,654	13,813	63,860	13,919	56,202
Not in bottles ....gallons	543,292	319,085	655,795	371,344	708,558	369,893	802,192	380,588	1,125,297	545,708
All other agricultural products		1,389,882		2,503,374		1,368,664		1,428,547		1,439,126
Total value of miscellaneous products		41,837,152		54,790,126		51,065,465		55,412,828		50,699,422
RECAPITULATION.										
Animals and animal matter		178,104,333		181,731,463		171,285,866		189,295,287		176,191,521
Bread and breadstuffs		128,121,656		299,363,117		200,312,654		166,777,229		114,604,780
Cotton and cotton-seed oil		294,688,203		263,443,526		192,699,001		216,877,694		211,714,303
Miscellaneous products		41,837,152		54,790,126		51,085,465		55,412,828		50,699,422
Total agricultural exports		642,751,344		799,328,232		615,382,986		628,363,038		553,210,026
Total exports		872,270,283		1,015,732,011		831,030,785		869,204,937		793,392,599
Per cent of agricultural matter		73.69		78.69		74.05		72.29		69.73

Table showing principal countries to which products of domestic agriculture were exported during the fiscal year ending June 30, 1895.

Articles.	Total.	Great Britain and Ireland.	British Possessions.	Germany.	France.	All other countries.
Animals:						
Cattle	$30,603,796	$28,492,424	$189,420	$621,920	$840,000	$460,032
Hogs	72,424	540	3,417	----------	----------	68,467
Horses	2,209,298	952,532	740,291	260,432	60,875	195,168
Mules	186,452	----------	96,185	----------	----------	90,267
Sheep	2,630,686	2,348,816	201,812	----------	39,936	40,122
All other, including fowls	51,389	8,885	12,521	19,845	----------	10,138
Total	35,754,045	31,803,197	1,243,646	902,197	940,811	864,194
Bones, horns, etc	288,084	130,261	40,631	12,250	14,403	90,539
Breadstuffs:						
Barley	767,228	621,112	16,224	----------	----------	129,892
Bread and biscuit	634,600	6,989	344,076	1,074	54	282,407
Corn	14,650,767	8,126,526	1,892,185	1,672,539	306,689	2,652,828
Corn meal	648,844	180,362	324,935	5,375	----------	138,172
Oats	200,793	2,725	127,974	368	81	69,645
Oatmeal	566,321	418,844	1,566	56,269	----------	89,642
Rye	5,340	4,800	450	----------	----------	90
Rye flour	12,062	----------	406	----------	----------	11,656
Wheat	43,805,663	30,453,104	2,644,282	1,522,736	945,594	8,239,947
Wheat flour	51,651,928	30,529,897	7,962,865	740,264	4,174	12,414,728
All other breadstuffs	1,661,234	532,503	418,361	108,634	10,659	591,077
Total	114,604,780	70,876,862	13,733,324	4,107,259	1,267,251	24,620,084
Bristles	3,901	3,087	814	----------	----------	----------
Broom corn	169,503	----------	145,242	----------	----------	24,261
Casings for sausages	1,581,891	353,980	106,255	594,060	47,565	480,031
Cider	85,675	83,722	359	1,125	----------	469
Cotton, unmanufactured	204,900,990	104,101,245	3,414,156	43,078,399	21,938,213	32,368,977
Eggs	25,317	307	18,223	----------	----------	6,787
Egg yolks	2,255	----------	50	----------	2,205	----------
Fruits and nuts	4,971,791	2,908,277	1,048,079	291,645	72,683	651,107
Feathers	215,681	72,004	17,579	113,931	278	11,889
Glucose or grape sugar	2,567,784	2,470,661	77,894	4,158	----------	15,071
Glue	114,493	45,387	41,864	14,530	100	12,612
Flowers, cut	2,521	743	1,778	----------	----------	----------
Grease, etc	904,071	323,467	321,291	116,126	3,707	139,480
Grasses	19,781	8,888	50	9,528	1,005	310
Hair, etc	505,029	324,053	21,009	12,498	25,349	122,120
Hay	699,029	471,613	43,542	10,796	16,945	156,133
Hides and skins, other than fur skins	2,310,323	251,247	1,088,091	308,630	428,512	233,843
Honey	118,873	23,060	1,030	66,839	----------	27,944
Hops	1,872,597	1,782,879	72,460	111	----------	17,147
Malt	110,323	56	32,549	----------	2,500	75,218
Mast	16,000	----------	----------	16,000	----------	----------
Oil cake and oil-cake meal	7,165,587	3,216,971	202,349	2,339,885	70,977	1,335,405
Oils:						
Animal	379,678	128,910	111,823	12,934	22,165	103,846
Cotton-seed	6,813,313	926,585	262,432	931,560	776,317	3,916,419
Linseed	37,363	----------	4,889	----------	----------	32,474
Total	7,230,354	1,055,495	379,144	944,494	798,482	4,052,739
Provisions:						
Meat products—						
Beef products—						
Beef, canned	5,720,933	3,562,993	305,739	518,260	558,165	775,776
Beef, fresh	16,832,860	16,784,936	9,776	27,183	----------	10,965
Beef, salted or pickled	3,558,230	1,643,509	652,453	541,750	22,131	698,387
Beef, other, cured	73,569	44,087	12,508	8,576	3,000	5,398
Tallow	1,293,059	227,908	46,475	121,390	42,573	854,713
Total	27,478,651	22,263,433	1,026,951	1,217,159	625,869	2,345,239
Hog products—						
Bacon	37,776,293	29,024,682	477,463	981,591	791,631	6,500,926
Hams	10,960,567	9,245,618	309,487	216,620	60,546	1,128,296
Pork, fresh	60,660	56,800	3,849	----------	----------	11
Pork, pickled	4,138,400	1,032,438	1,338,945	144,169	18,329	1,604,519
Lard	36,821,508	14,301,618	437,258	8,018,516	2,681,659	11,382,457
Total	89,757,428	53,661,156	2,567,002	9,360,896	3,552,165	20,616,209
Mutton	47,832	26,370	12,824	6,455	----------	2,183

Table showing principal countries to which products of domestic agriculture were exported during the fiscal year ending June 30, 1895—Continued.

Articles.	Total.	Great Britain and Ireland	British Possessions.	Germany.	France.	All other countries.
Provisions—Continued.						
Meat products—Continued.						
Oleomargarine—						
Imitation butter	$992,464	$115,924	$174,850	$123,363	....	$578,327
The oil	7,107,018	623,145	61,181	1,839,310	....	4,583,382
Total	8,099,482	739,069	236,031	1,962,673	....	5,161,709
Poultry and game	17,898	4,575	10,811	243	....	2,269
All other meat products	1,600,231	758,722	219,055	240,197	$15,520	$366,737
Dairy products—						
Butter	915,533	134,955	237,514	12,978	....	530,086
Cheese	5,497,539	4,362,877	1,036,849	553	2,000	95,260
Milk	219,785	31,955	46,516	76	100	141,138
Total	6,632,857	4,529,787	1,320,879	13,607	2,100	766,484
Total provisions	133,634,379	81,983,112	5,393,553	12,801,230	4,195,654	29,260,830
Rice	4,687	1,784	365	229	....	2,309
Roots, herbs, etc	1,058,808	57,982	764,894	74,217	13,214	148,501
Seeds:						
Clover	2,124,997	996,123	316,097	584,469	25,590	202,718
Cotton	86,695	76,160	257	99	124	10,055
Flaxseed or linseed	1,433	876	547	....	....	10
Timothy	277,160	114,616	84,494	61,209	975	15,866
All other	358,860	127,479	70,224	27,128	13,068	120,961
Total	2,849,145	1,315,254	471,619	672,905	39,757	349,610
Straw	3,639	3,218	371	....	16	34
Sugar, brown, molasses, and sirup	872,452	688,635	107,163	19,421	8,422	48,811
Tobacco, leaf, stems, and trimmings	25,798,968	9,295,946	1,762,769	3,910,388	2,901,098	7,928,767
Vegetables:						
Beans and peas	429,002	7,392	75,746	794	2,900	342,170
Onions	46,703	....	18,681	68	....	27,954
Potatoes	418,221	1,838	47,337	1	....	369,045
Vegetables, canned	441,388	338,805	31,854	2,317	1,999	66,413
All other, including pickles	208,144	69,475	84,851	1,312	476	52,030
Total	1,543,458	417,510	258,469	4,492	5,375	857,612
Wax, bees'	90,875	38,594	337	50,617	....	1,327
Wine	601,910	59,465	12,056	164,126	3,669	362,594
Wool	484,463	12,636	271,328	4,892	638	194,969
Total [1]	553,183,462	314,181,598	31,094,333	70,646,978	32,798,829	104,461,724
Per cent	....	56.80	5.62	12.77	5.93	18.88

[1] Unenumerated articles, amounting to $26,564, make up the total to $553,210,026.

SURVEYORS' MEASURE.

7.92 inches	= 1 link.
25 links	= 1 rod = $5\frac{1}{2}$ yards.
100 links	= 1 chain = 4 rods = 22 yards.
80 chains	= 1,760 yards = 1 mile.
10 square chains or 160 square rods	= 1 acre.
640 acres	= 1 square mile.

An acre of ground comprised within four equal sides measures 208.71 feet each way.

A half acre of ground comprised within four equal sides measures 147.581 feet each way.

A circular acre is 235.504 feet in diameter.

A circular half acre is 166.52 feet in diameter.

IMPORTS OF AGRICULTURAL PRODUCTS FOR THE YEARS ENDING JUNE 30, 1891 TO 1895.

Articles.	1891.		1892.		1893.		1894.		1895.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animals and their products, except wool:										
Animals, live—										
Cattle ....number	12,392	$102,978	2,168	$47,466	3,293	$45,682	1,592	$18,704	149,781	$765,853
Horses ....do	22,537	3,265,254	14,074	2,455,868	15,451	2,388,267	6,166	1,319,572	13,098	1,055,191
Sheep ....do	345,765	1,219,206	380,814	1,440,530	459,484	1,682,977	242,568	788,181	291,461	682,618
All other, including fowls	....	357,927	....	307,752	....	525,269	....	274,789	....	233,416
Animal products, except wool:										
Beeswax ....pounds	379,135	80,485	271,068	65,487	248,000	62,024	318,660	80,024	288,001	78,776
Bones, crude	....	322,009	....	345,668	....	360,573	....	307,033	....	306,049
Bristles ....pounds	1,404,832	1,357,938	1,495,003	1,455,058	1,598,818	1,508,258	892,520	929,231	1,301,494	1,244,151
Eggs ....dozen	8,233,043	1,185,595	4,188,492	522,240	3,318,011	392,973	1,791,430	199,536	2,705,502	324,136
Feathers and downs, crude	....	385,134	....	443,776	....	654,337	....	263,849	....	1,746,967
Glue ....pounds	5,501,142	497,340	5,541,776	495,519	6,170,162	567,756	4,132,524	400,240	4,751,048	416,394
Grease ....do	16,372,186	430,335	....	271,421	....	419,625	11,093,737	256,287	....	1,331,908
Gut, unmanufactured	....	242,950	....	225,278	....	229,261	....	188,111	....	212,645
Hair	....	2,265,714	....	1,685,562	....	2,005,796	....	839,972	....	1,165,944
Hide cuttings and all other glue stock	....	353,943	....	303,302	....	365,525	....	280,062	....	263,175
Hides and skins	....	27,930,759	....	26,850,218	....	28,347,896	....	16,786,152	....	26,122,942
Honey ....gallons	47,740	20,808	70,103	31,418	176,147	79,396	152,643	56,156	67,444	22,993
Hoofs, horns, and parts of, unmanufactured	....	587,444	....	797,529	....	554,902	....	235,232	....	268,800
Oils, animal ....gallons	19,307	5,531	34,543	12,136	55,619	21,327	3,597	1,232	1,464	469
Meats and meat extracts	....	521,322	....	430,048	....	558,284	....	412,666	....	479,336
All other meat products	....	66,385	....	15,386	....	16,717	....	12,291	....	5,244
Butter ....pounds	380,728	58,541	114,137	16,549	73,423	13,479	144,346	23,356	72,148	12,930
Cheese ....do	8,863,640	1,358,752	8,305,288	1,238,166	10,195,924	1,425,927	8,742,851	1,247,198	10,276,293	1,450,657
Milk	....	103,891	....	95,947	....	110,186	....	102,336	....	80,491
Rennets	....	89,869	....	116,460	....	109,358	....	76,063	....	84,415
Sausage skins	....	572,817	....	566,650	....	583,217	....	495,118	....	419,345
Total value of animals and their products, except wool	....	43,382,927	....	40,235,434	....	43,029,012	....	25,593,391	....	38,774,845
Breadstuffs:										
Barley ....bushels	5,078,733	3,222,593	3,146,328	1,592,040	1,970,129	921,605	791,061	358,744	2,116,816	867,743
Corn (maize) ....do	2,111	1,651	15,290	10,752	1,881	1,265	2,199	1,508	16,575	7,552
Oats ....do	9,692	5,056	20,208	8,224	21,309	8,897	8,345	3,928	308,308	80,901
Oatmeal ....pounds	578,809	31,089	496,333	27,942	506,232	25,642	421,459	24,483	396,176	21,993
Rye ....bushels	140,737	98,227	83,537	67,507	8,598	7,055	50	37	12,918	6,272
Wheat ....do	545,968	431,940	2,459,602	1,955,385	966,280	707,053	1,181,060	769,177	1,429,993	868,965

Wheat flour .... barrels..	8,413	43,180	614	4,231	410	2,223	401	1,946	1,868	8,295
All other	....	1,194,473	....	1,223,066	....	1,266,835	....	1,042,064	....	998,092
Total value of breadstuffs	....	5,028,209	....	4,889,147	....	2,940,575	....	2,201,887	....	2,850,813
Fibers:										
Animal—										
Wools .... pounds..	129,303,648	18,231,372	148,670,652	19,688,108	172,433,838	21,064,180	55,152,585	6,107,438	206,033,906	25,556,421
Silk	....	19,076,081	....	25,059,325	....	29,836,986	....	16,234,182	....	22,626,056
Vegetable—										
Cotton .... pounds..	20,908,817	2,825,004	28,663,769	3,217,521	43,367,952	4,688,799	27,705,949	3,003,888	49,332,022	4,714,375
Flax .... tons..	6,331	1,656,779	7,812	1,964,163	6,696	1,879,152	4,352	1,336,845	7,233	2,059,291
Hemp .... do...	11,484	1,731,396	5,187	681,809	4,817	685,485	1,635	239,918	6,954	882,761
Istle or tampico[1] .... do...	3,877	353,181	4,732	325,548	4,987	321,869	4,789	257,089	9,827	458,404
Jute and jute butts .... do...	141,704	3,862,858	88,624	3,021,174	82,231	2,467,828	50,037	1,716,298	110,671	2,752,966
Manila[1] .... do...	35,331	6,218,254	44,574	6,672,279	59,439	8,376,370	35,233	4,013,255	50,278	4,060,517
Sisal grass[1] .... do...	39,213	4,454,573	48,020	5,187,620	54,431	6,005,484	48,468	3,742,073	47,596	2,743,396
All other .... do...	33,650	3,009,664	12,824	1,271,501	16,303	1,635,367	10,207	858,003	6,152	324,746
Total value of fibers	....	61,419,162	....	67,089,048	....	76,961,520	....	37,508,989	....	66,178,933
Sugar and molasses:										
Sugar .... pounds..	3,483,477,222	105,728,216	3,556,509,165	104,408,813	3,766,445,347	116,255,784	4,345,193,881	126,871,889	3,574,510,454	76,462,836
Molasses .... gallons..	20,604,463	2,659,172	22,448,209	2,877,744	15,490,679	1,992,334	19,670,663	1,984,778	15,075,879	1,295,146
Total value of sugar and molasses	....	108,387,388	....	107,286,557	....	118,248,118	....	128,856,667	....	77,757,982
Tea, coffee, cocoa, and substitutes:										
Tea .... pounds..	83,453,339	13,828,993	90,079,039	14,373,222	89,061,287	13,857,482	93,518,717	14,144,243	97,253,458	13,171,379
Coffee .... do....	519,528,432	96,123,777	640,210,788	128,041,930	563,469,068	80,485,558	550,934,337	90,314,676	652,208,975	96,130,717
Cocoa, crude, and leaves and shells of .... pounds..	21,539,840	2,817,168	21,955,874	3,221,041	24,460,325	4,017,801	17,634,779	2,402,382	29,307,048	3,195,811
Chicory root, raw, unground ... do....	1,864,821	35,512	5,492,732	93,179	6,689,332	134,070	7,951,042	168,892	9,544,186	158,142
Coffee substitutes .... do....	76,593	4,842	2,184,348	83,159	1,729,124	64,298	1,389,672	55,554	2,776,117	106,886
Total value of tea, coffee, cocoa, and substitutes	....	112,810,292	....	145,812,531	....	98,559,209	....	107,085,747	....	112,762,935
Miscellaneous:										
Fruits and nuts	....	25,983,136	....	20,943,906	....	23,687,422	....	18,754,771	....	17,239,923
Hay .... tons..	58,242	445,461	79,715	715,151	104,257	964,755	86,784	761,940	201,900	1,433,716
Hops .... pounds..	4,019,603	1,797,406	2,506,224	883,701	2,691,244	1,085,407	828,022	484,415	3,133,664	599,744
Indigo .... do....	2,089,007	1,600,630	2,461,667	1,772,507	3,226,312	3,137,511	1,718,534	1,218,576	3,956,986	2,015,975
Malt, barley .... bushels..	123,083	78,433	5,165	6,148	3,559	4,411	5,010	5,676	11,069	7,495
Oil cake .... pounds..	2,739,323	23,846	10,366,156	106,811	7,302,527	82,916	7,600,871	37,588	6,794,531	47,774
Oils, vegetable—										
Fixed or expressed—										
Olive salad .... gallons..	605,509	733,489	706,486	876,613	686,852	891,424	757,478	909,897	775,046	952,405
Other	....	1,465,001	....	2,239,540	....	2,754,372	....	1,730,797	....	2,570,035
Volatile or essential ..... pounds..	3,459,533	1,523,491	3,451,519	1,676,064	4,022,117	1,654,036	2,861,875	1,102,108	....	1,398,956

[1] Included in all other fibers prior to October 6, 1890.

IMPORTS OF AGRICULTURAL PRODUCTS FOR THE YEARS ENDING JUNE 30, 1891 TO 1895—Continued.

Articles.	1891.		1892.		1893.		1894.		1895.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Miscellaneous—Continued.										
Opium, crude .... pounds..	466,554	$1,202,375	587,118	$1,029,203	615,957	$1,186,824	716,881	$1,691,914	358,455	$730,669
Plants, trees, and flowers........	....	189,763	....	155,018	....	137,503	....	124,143	....	632,523
Rice and rice meal........	....	4,559,540	....	3,030,883	....	2,790,151	....	2,374,835	....	3,445,512
Seeds	....	3,266,230	....	2,264,837	....	2,757,010	....	2,395,603	....	6,535,580
Spices—										
Ground .... pounds..	1,769,026	262,682	2,381,248	307,738	2,488,466	298,008	1,664,246	257,845	2,058,782	272,223
Unground—										
Nutmegs........ do....	1,327,135	686,019	1,580,605	750,813	1,419,636	613,743	1,140,878	395,977	1,652,613	513,801
Pepper .... do....	13,564,583	1,338,637	14,799,322	1,069,268	21,467,275	1,278,062	12,764,215	665,576	20,501,837	791,343
All other .... do....	13,732,261	864,495	14,511,451	920,006	16,862,214	1,110,197	14,857,688	943,155	17,879,564	1,062,868
Straw .... tons..	7,178	25,521	5,002	18,798	8,892	30,681	8,313	27,300	7,745	24,544
Tobacco, leaf........ pounds..	23,061,008	13,284,162	21,988,535	10,332,423	28,110,378	14,702,440	19,663,259	10,985,386	26,668,261	14,745,720
Vanilla beans .... do....	170,923	594,744	242,639	803,696	238,733	763,935	171,556	727,853	137,296	495,273
Vegetables—										
Beans and peas........ bushels..	1,656,768	2,078,571	874,050	957,824	1,754,943	1,734,228	1,184,081	1,117,969	1,535,960	1,548,767
Potatoes........ do....	5,401,912	2,797,927	186,871	186,006	4,317,021	2,066,589	3,002,578	1,277,194	1,341,533	603,554
Pickles and sauces	....	511,163	....	421,292	....	454,099	....	341,135	....	321,632
All other........	....	1,688,713	....	1,318,105	....	1,331,773	....	1,158,769	....	1,497,583
Vinegar........ gallons..	76,378	20,009	67,970	18,191	66,834	19,295	68,542	18,501	75,108	19,823
Wines—										
Champagne and other sparkling, dozen bottles........	400,084	5,615,872	319,592	4,571,816	374,124	5,579,054	237,360	3,498,522	257,757	3,807,961
Still wines—										
In casks........ gallons..	3,860,503	2,041,816	3,477,989	2,464,484	3,525,625	2,505,024	2,599,693	1,817,813	2,789,153	1,945,347
In bottles........ dozen..	348,666	1,749,372	365,140	1,908,203	413,860	2,121,275	296,097	1,423,143	296,779	1,430,229
Total value of miscellaneous products........	....	77,028,504	....	61,749,045	....	75,742,145	....	56,248,401	....	66,690,975
RECAPITULATION.										
Animals and their products, except wool.	....	43,382,927	....	40,235,434	....	43,029,012	....	25,593,391	....	38,774,845
Breadstuffs	....	5,028,209	....	4,889,147	....	2,940,575	....	2,201,887	....	2,859,813
Fibers........	....	61,419,162	....	67,069,048	....	76,961,520	....	37,508,989	....	66,178,933
Sugar and molasses	....	108,387,388	....	107,286,557	....	118,248,118	....	128,856,667	....	77,757,982
Tea, coffee, cocoa, and substitutes........	....	112,810,292	....	145,812,531	....	98,559,209	....	107,085,747	....	112,762,935
Miscellaneous	....	77,028,504	....	61,749,045	....	75,742,145	....	56,248,401	....	66,690,975
Total agricultural imports	....	408,056,482	....	427,061,762	....	415,480,579	....	357,495,082	....	365,025,483
Total imports........	....	844,916,196	....	827,402,462	....	866,400,922	....	654,994,622	....	731,969,965
Per cent of agricultural matter.	....	48.30	....	51.61	....	47.95	....	54.58	....	49.87

TOTAL VALUES OF EXPORTS OF DOMESTIC MERCHANDISE SINCE 1890.

Year ending June 30—	Agricultural.		Other nonmanufactured.		Manufactured.		Total values.
	Values.	Per cent.	Values.	Per cent.	Values.	Per cent.	
1890	$629,820,808	74.51	$64,370,644	7.62	$151,102,376	17.87	$845,293,828
1891	642,751,344	73.69	60,591,624	6.94	168,927,315	19.37	872,270,283
1892	799,328,232	78.69	57,892,842	5.70	158,510,937	15.61	1,015,732,011
1893	615,382,986	74.05	57,624,681	6.93	158,023,118	19.02	831,030,785
1894	628,363,038	72.28	57,113,091	6.58	183,728,808	21.14	869,204,937
1895	553,210,026	69.73	56,586,830	7.13	183,595,743	23.14	793,392,599

EXPORTS OF RAW COTTON FROM THE UNITED STATES SINCE 1890.

Year ending June 30—	Pounds.	Per cent of total crop.	Average export price per pound.
			Cents.
1890	2,471,799,853	68.15	10.1
1891	2,907,358,795	67.36	10.0
1892	2,935,219,811	65.13	8.7
1893	2,212,115,126	65.99	8.5
1894	2,683,282,325	71.20	7.8
1895	3,517,433,109	69.83	5.8

PRODUCTION OF CERTAIN FRUITS AND NUTS, MOSTLY SEMI-TROPIC, IN THE UNITED STATES IN 1889 AND THE QUANTITIES AND VALUES IMPORTED FROM 1890 TO 1895, INCLUSIVE.

Products.	Total value of United States crop in 1889.	Imported during year ending June 30—					
		1890.	1891.	1892.	1893.	1894.	1895.
Oranges [1]	$6,602,099	$1,916,652	$2,339,987	$1,210,338	$1,695,469	$1,127,065	$1,997,266
Lemons	988,100	3,374,032	4,351,970	4,548,263	4,994,328	4,285,278	3,917,326
Limes [1]	62,497	[2]67,567	[2]59,867	[2]37,829	[2]47,196	[2]48,764	[2]28,104
Bananas [1]	280,654	4,653,779	5,854,752	5,000,632	5,361,187	5,122,503	4,674,861
Figs [1]	307,272	456,567	697,562	511,142	548,995	392,040	587,420
		[3]10,284,998	[3]9,201,565	[3]8,338,759	[3]10,503,928	[3]7,985,959	[3]11,855,890
Dates	[4]	[2]335,864	[2]661,596	551,629	493,910	387,586	316,592
		[5]10,994,485	[5]20,091,012	[3]17,084,557	[3]16,211,906	[3]12,408,192	[3]15,186,789
Cocoanuts	251,217	822,810	918,233	917,564	852,509	786,777	471,994
Pineapples [1]	812,159	[2]550,243	[2]558,288	[2]746,561	[2]743,861	[2]753,129	[2]314,039
Olives	386,368	[2]211,817	[2]320,164	[2]417,882	[2]510,535	[2]378,863	[2]325,352
Raisins	2,195,512	1,997,103	2,018,879	964,309	1,266,342	554,081	651,420
	[3]27,443,900	[3]36,914,330	[3]39,572,655	[3]20,687,640	[3]27,543,563	[3]13,751,050	[3]15,921,278
Currants	[4]	[2]875,427	[2]1,577,852	1,209,119	1,185,537	774,802	258,659
		[5]26,895,589	[5]42,849,814	[3]36,665,828	[3]33,166,546	[3]52,664,843	[3]16,450,706
Plums and prunes	[3]127,719,600	1,789,176	2,054,486	437,271	1,162,318	416,342	527,615
	[4]	[3]58,093,410	[3]34,281,322	[3]10,869,797	[3]26,414,112	[3]9,908,122	[3]14,352,057
Almonds	1,525,110	813,278	931,007	1,028,671	938,054	769,453	810,439
		[3]5,715,858	[3]6,812,061	[3]7,629,392	[3]6,679,147	[5]7,436,784	[3]7,903,375

[1] Returns from a few districts not quite complete.
[2] Entered for consumption.
[3] Quantity in pounds.
[4] Value of crop not ascertained.
[5] Quantity in pounds entered for consumption.

STATISTICS OF FRUIT AND VEGETABLE CANNING IN THE UNITED STATES.

[From the census of 1890.]

Capital employed	$15,315,185
Average number of employees	50,881
Wages paid during the year	$5,243,707
Cost of materials used	$18,665,163
Total value of products	$29,862,416

The capital employed in this industry was only $701,388 less than was employed in the creamery and cheese-factory business, while the value of the products exceeded the combined value of all the windmills, clocks, watches, firearms, mirrors, mats and matting, linen fabrics, and enameled goods manufactured in the United States during the same year.

AVERAGE PRICE AND CONSUMPTION OF SUGAR.

Average price per pound of "Standard A" sugar in the New York market and average consumption of sugar of all grades, per capita of population, in the United States from 1878 to 1894.

Calendar year.	Average price per pound.	Consumption per capita of population.	Calendar year.	Average price per pound.	Consumption per capita of population.
	Cents.	*Pounds.*		*Cents.*	*Pounds.*
1878	8.94	34.3	1887	5.66	52.7
1879	8.53	40.7	1888	6.69	56.7
1880	9.48	42.9	1889	7.59	51.8
1881	9.84	44.2	1890	6.00	52.8
1882	8.87	48.4	1891	4.47	66.1
1883	8.14	51.1	1892	4.21	63.5
1884	6.37	53.4	1893	4.72	63.9
1885	6.06	51.8	1894	4.00	66.4
1886	5.81	56.9			

TEA, COFFEE, WINES, ETC.

Consumption of tea, coffee, wines, distilled spirits, and malt liquors in the United States since 1870, per capita of population.

Year ending June 30—	Tea.	Coffee.	Wines.	Distilled spirits.	Malt liquors.
	Pounds.	*Pounds.*	*Gallons.*	*Proof gals.*	*Gallons.*
1870	1.10	6.00	0.32	2.07	5.31
1871	1.14	7.91	.40	1.62	6.10
1872	1.46	7.28	.41	1.68	6.66
1873	1.53	6.87	.45	1.63	7.21
1874	1.27	6.59	.48	1.51	7.00
1875	1.44	7.08	.45	1.50	6.71
1876	1.35	7.33	.45	1.33	6.83
1877	1.23	6.94	.47	1.28	6.58
1878	1.33	6.24	.47	1.09	6.68
1879	1.21	7.42	.50	1.11	7.05
1880	1.39	8.78	.56	1.27	8.26
1881	1.54	8.25	.47	1.38	8.65
1882	1.47	8.30	.49	1.40	10.03
1883	1.30	8.91	.48	1.46	10.27
1884	1.09	9.26	.37	1.48	10.74
1885	1.18	9.60	.39	1.26	10.62
1886	1.37	9.36	.45	1.26	11.20
1887	1.49	8.53	.55	1.21	11.23
1888	1.40	6.81	.61	1.26	12.80
1889	1.29	9.16	.56	1.32	12.72
1890	1.33	7.83	.46	1.40	13.67
1891	1.29	7.99	.45	1.42	15.28
1892	1.37	9.61	.44	1.50	15.10
1893	1.32	8.24	.48	1.51	16.08
1894	1.34	8.01	.31	1.33	15.18
1895	1.38	9.22	.28	1.12	14.95

FREIGHT RATES (ALL RAIL) IN EFFECT JANUARY 1, 1892 TO 1896, IN CENTS PER 100 POUNDS.

From—	To—	Wheat (carloads).					Corn (carloads).					Potatoes (carloads).					Wool, in bales (carloads).					Pickled pork, in barrels (carloads).				
		1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1893.	1892.	1893.	1894.	1895.	1896.
Cincinnati, Ohio	Boston, Mass.[1]	26½	23½	23½	23½	19	26½	23½	23½	23½	19	31	29	29	29	29	62½	52	62½	62½	62½	31	29	29	29	29
	New York, N.Y.	21½	21½	21½	21½	17	21½	21½	21½	21½	17	26	26	26	26	26	56½	46	56½	56½	56½	26	26	26	26	26
	Philadelphia, Pa	19½	19½	19½	19½	15	19½	19½	19½	19½	15	24	24	24	24	24	54½	44	54½	54½	54½	24	24	24	24	24
	Baltimore, Md	18½	18½	18½	18½	14	18½	18½	18½	18½	14	23	23	23	23	23	53½	43	53½	53½	53½	23	23	23	23	23
Indianapolis, Ind	Boston, Mass.[1]	28	25	25	25	21½	28	25	25	25	21½	33	31	31	31	31	66½	56½	66½	66½	66½	33	31	31	31	31
	New York, N.Y.	23	23	23	23	19½	23	23	23	23	19½	28	28	28	28	28	60½	49½	60½	60½	66½	28	28	28	28	28
	Philadelphia, Pa	21	21	21	21	17½	21	21	21	21	17½	26	26	26	26	26	58½	47½	58½	58½	58½	26	26	26	26	26
	Baltimore, Md	20	20	20	20	16½	20	20	20	20	16½	25	25	25	25	25	57½	46½	57½	57½	57½	25	25	25	25	25
Chicago, Ill	Boston, Mass.[1]	30	27	27	27	22	30	27	27	27	22	35	33	33	33	33	71	59	71	71	71	35	33	33	33	33
	New York, N.Y.	25	25	25	25	20	25	25	25	25	20	30	30	30	30	30	65	53	65	65	65	30	30	30	30	30
	Philadelphia, Pa	23	23	23	23	18	23	23	23	23	18	28	28	28	28	28	63	51	63	63	63	28	28	28	28	28
	Baltimore, Md	22	22	22	22	17	22	22	22	22	17	27	27	27	27	27	62	50	62	62	62	27	27	27	27	27
East St. Louis, Ill	Boston, Mass.[1]	34	31	31	31	25	54	31	31	31	25	40	38	38	38	38	81½	63½	81½	81½	81½	40	38	38	38	38
	New York, N.Y.	29	29	29	29	23	29	29	29	29	23	35	35	35	35	35	75½	61½	75½	75½	75½	35	35	35	35	35
	Philadelphia, Pa	27	27	27	27	21	27	27	27	27	21	33	33	33	33	33	73½	59½	73½	73½	73½	33	33	33	33	33
	Baltimore, Md	26	26	26	26	20	26	26	26	26	20	32	32	32	32	32	72½	58½	72½	72½	72½	32	32	32	32	32

[1] On traffic for export New York rates apply to Boston.

FREIGHT RATES ON WHEAT FROM NEW YORK TO LIVERPOOL.

Year.	Rates (in cents per bushel).											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1875	21.94	18.82	14.56	12.34	13.94	16.00	......	......	......	......	......	......
1880	7.00	7.62	12.00	11.90	9.00	10.12	14.60	14.76	11.38	12.30	15.12	14.62
1885	9.30	5.32	7.30	8.38	5.60	5.00	4.76	5.30	7.72	5.70	5.12	6.48
1890	11.13	10.75	8.00	4.00	4.13	3.75	4.25	2.00	1.38	.38	4.50	5.00
1891	7.25	4.75	3.00	3.00	3.25	4.00	4.00	6.00	8.63	11.13	11.50	8.75
1892	9.00	6.38	7.50	3.75	4.88	4.00	5.50	4.25	4.00	6.00	4.88	......
1893	3.00	3.25	2.75	2.63	3.75	5.88	6.50	7.13	4.38	5.25	6.00	5.83
1894	6.25	4.75	4.63	4.25	2.38	3.50	2.88	1.63	1.75	2.25	5.63	5.88

FREIGHT RATES (ALL RAIL) ON LIVE STOCK AND DRESSED MEATS FROM CHICAGO TO NEW YORK.

Year.	Rates (in cents per 100 pounds).						
	Cattle.	Hogs.	Sheep.	Horses and mules.	Dressed beef.	Dressed hogs, refrigerator cars.	Dressed hogs, common cars.
1875	......	......	......	......	70.00	......	......
1880	55.00	41.25	65.00	65.00	88.00	......	......
1885	29.00	25.00	42.00	60.00	50.60	......	......
1890	21.69	25.42	30.00	60.00	37.40	37.40	37.40
1891	28.00	30.00	30.00	60.00	45.00	45.00	45.00
1892	28.00	24.37	30.00	60.00	45.00	45.00	45.00
1894	28.00	28.33	30.00	60.00	45.00	45.00	45.00
1895	28.00	25.00	30.00	60.00	45.00	45.00	45.00

THE WEATHER IN 1895.

Highest and lowest temperatures, with the highest and lowest ever recorded.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year 1895.	Ever recorded.
Boston, Mass	54	46	58	80	90	96	85	89	96	70	73	64	96	102
	4	−6	14	27	36	50	54	50	42	32	21	8	−6	−13
Philadelphia, Pa	55	53	64	84	94	97	94	98	97	74	74	66	98	102
	10	−3	18	32	40	54	57	56	45	34	26	13	−3	−5
Charleston, S. C	72	76	81	82	89	97	95	98	91	88	80	72	98	104
	22	12	34	45	51	64	67	71	64	49	37	30	12	10
Jacksonville, Fla	79	76	84	85	90	96	96	97	94	89	84	80	97	104
	26	14	40	45	55	62	70	70	64	52	35	28	14	14
Indianapolis, Ind	58	68	82	85	96	100	94	100	94	78	73	62	100	101
	−13	−14	14	31	33	54	49	53	35	22	17	9	−14	−25
Springfield, Ill	60	65	84	88	92	95	94	93	94	75	72	59	95	102
	−10	−20	12	29	34	55	54	56	36	21	9	4	−20	−22
Davenport, Iowa	54	64	82	87	90	92	96	94	92	74	70	55	96	100
	−13	−20	6	30	34	54	52	55	34	20	9	2	−20	−27
Memphis, Tenn	72	74	87	88	94	98	97	95	96	81	74	69	98	102
	7	−3	28	38	47	60	64	62	45	37	27	20	−3	−8
New Orleans, La	77	74	81	87	87	93	94	92	94	87	81	75	94	99
	27	16	39	50	58	68	71	70	57	52	37	34	16	15
Moorhead, Minn	25	57	59	82	92	85	92	91	91	81	61	43	92	102
	−29	−34	−19	22	28	38	44	35	24	3	−12	−17	−34	−48
Des Moines, Iowa	64	64	88	85	94	89	98	95	94	75	74	57	98	104
	−14	−18	3	27	35	50	48	51	32	15	2	0	−18	−30
Springfield, Mo	70	66	86	84	86	89	91	91	92	76	70	60	92	102
	−12	−17	10	34	40	56	55	59	37	28	16	4	−17	−17
Little Rock, Ark	73	72	87	88	88	94	96	95	96	84	76	69	96	103
	12	−2	25	36	46	62	66	65	45	38	28	17	−2	−5
Lincoln, Nebr	65	69	90	85	98	-----	102	98	101	78	73	-----	-----	-----
	−12	−18	1	32	34	-----	49	53	28	15	1	-----	-----	-----
Wichita, Kans	69	68	91	92	95	101	101	95	100	83	74	66	101	-----
	−1	−13	7	33	40	52	55	59	34	29	14	6	−13	-----
Palestine, Tex	78	76	85	87	88	92	96	98	100	87	79	73	100	103
	18	−1	27	37	50	62	68	65	48	43	29	24	−1	−1
Corpus Christi, Tex	80	75	78	88	85	90	89	93	88	90	80	75	93	98
	32	16	38	51	58	70	76	73	62	53	38	28	16	16
Helena, Mont	51	65	69	75	79	89	94	91	85	75	61	51	94	103
	−15	−17	−10	24	31	35	43	40	26	25	1	−4	−17	−42
Denver, Colo	62	63	76	76	92	90	95	94	96	80	75	69	96	105
	−7	−15	−1	22	33	40	45	51	27	21	2	5	−15	−29
Walla Walla, Wash	63	66	72	86	90	98	104	102	83	84	69	60	104	108
	11	18	19	31	38	43	48	47	36	30	21	18	11	−17
Sacramento, Cal	60	68	70	86	94	102	98	99	95	88	75	65	102	108
	30	39	34	41	46	50	51	51	46	44	33	28	28	19
Los Angeles, Cal	77	84	84	82	88	100	85	88	97	91	94	86	100	109
	37	36	38	41	47	47	54	51	48	45	36	34	34	28

Monthly and total annual precipitation, in 1895 (in inches and hundredths), with the normal for purposes of comparison.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total, 1895.	Normal.	Period (years).
Boston, Mass	3.79	1.11	2.72	3.65	2.71	1.73	2.98	3.24	1.53	6.19	8.07	2.45	40.17	44.95	25
Philadelphia, Pa	4.52	1.39	2.61	6.14	1.72	3.15	3.23	0.59	0.61	2.97	2.32	1.76	31.01	39.89	24
Charleston, S.C	7.68	4.47	5.22	4.21	5.63	4.25	6.46	5.08	6.94	0.77	2.44	2.03	55.18	56.74	25
Jacksonville, Fla	4.63	3.61	3.63	4.40	2.26	4.98	11.21	2.54	4.66	0.58	3.12	1.18	46.80	52.26	25
Indianapolis, Ind	3.12	0.86	1.30	1.96	1.07	1.49	2.87	1.91	7.46	0.83	5.81	4.86	33.54	43.34	24
Springfield, Ill	1.12	1.03	1.61	2.49	2.55	3.49	5.53	2.76	2.80	0.27	3.28	8.08	35.01	38.10	16
Davenport, Iowa	1.27	0.38	1.57	0.32	2.28	1.22	5.16	4.79	4.30	0.81	2.50	2.54	27.14	33.80	24
Memphis, Tenn	5.94	1.39	7.01	2.32	0.46	2.31	6.99	0.64	0.73	2.17	5.54	3.09	38.59	53.28	24
New Orleans, La	7.19	3.92	3.81	2.58	7.95	9.74	6.07	6.79	1.97	1.21	0.69	4.52	56.44	60.53	25
Moorhead, Minn	0.33	0.37	0.03	1.46	1.34	5.62	3.05	1.49	1.45	0.21	1.88	0.15	17.38	23.76	15
Des Moines, Iowa	1.30	0.60	0.50	3.41	2.86	5.26	3.10	3.57	3.20	0.29	0.85	1.86	26.80	33.34	17
Springfield, Mo	2.33	0.81	4.70	1.10	3.54	3.87	7.86	4.57	3.66	0.78	3.22	11.02	47.46	45.93	9
Little Rock, Ark	7.12	0.63	7.78	1.47	2.85	9.25	6.13	3.96	0.41	2.22	5.26	2.50	49.58	53.91	16
Lincoln, Nebr	0.20	0.71	0.50	1.88	0.76	-----	1.05	4.00	0.64	0.05	0.79	-----	-----	-----	-----
Wichita, Kans	0.57	1.19	1.81	0.40	2.77	4.47	2.74	7.67	0.86	0.81	1.80	1.37	26.46	28.61	7
Palestine, Tex	2.42	2.50	2.52	2.35	11.38	5.29	3.85	0.06	1.05	3.73	4.23	4.34	43.72	45.94	12
Corpus Christi, Tex	0.31	3.49	1.43	2.41	5.57	3.80	0.00	1.17	1.68	1.08	4.14	0.64	25.72	29.13	8
Helena, Mont	1.95	1.69	0.29	0.53	0.87	1.30	1.18	0.14	0.57	0.28	0.77	1.12	10.69	13.20	14
Denver, Colo	0.32	0.48	1.19	1.19	2.86	2.65	4.28	0.76	0.98	1.13	0.27	0.01	16.12	14.50	24
Walla Walla, Wash	2.52	0.55	1.17	1.23	2.31	0.04	0.50	0.23	2.13	0.00	1.67	2.54	14.89	16.81	10
Sacramento, Cal	8.42	1.84	1.20	0.86	0.51	0.00	0.04	T.	1.26	0.17	1.54	1.54	17.38	21.11	18
Los Angeles, Cal	5.84	0.46	3.77	0.46	0.19	0.01	T.	T.	T.	0.24	0.80	0.78	12.55	17.36	18

Mean relative humidity, with the normal for purposes of comparison.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean, 1895.	Normal.
Boston, Mass	71.6	62.2	64.2	66.8	65.2	74.9	71.6	68.6	71.3	69.5	83.4	74.8	70.0	72
Philadelphia, Pa	75.8	67.8	63.1	68.2	69.7	72.2	65.4	66.0	67.3	60.8	77.6	69.8	69.0	70
Charleston, S.C	79.6	72.0	78.0	77.4	78.4	75.3	77.2	79.0	80.8	70.9	83.8	80.8	78.0	80
Jacksonville, Fla	78.5	72.6	73.0	72.1	78.6	74.5	79.8	81.6	82.8	78.4	84.0	79.8	78.0	78
Indianapolis, Ind	77.4	71.8	66.8	63.8	62.0	57.6	66.8	63.4	69.5	60.2	73.4	78.2	68.0	69
Springfield, Ill	71.0	75.8	63.5	67.2	63.0	57.6	67.6	68.4	72.0	55.6	74.8	77.3	68.0	71
Davenport, Iowa	77.6	77.8	58.8	59.1	61.7	58.5	63.2	63.8	73.2	62.4	74.3	81.2	68.0	71
Memphis, Tenn	73.5	63.6	79.8	63.8	67.4	71.2	83.5	75.1	72.6	64.2	73.8	72.0	72.0	73
New Orleans, La	80.2	79.7	77.2	72.9	79.4	78.2	73.4	80.8	74.5	66.4	77.0	74.0	77.0	77
Moorhead, Minn	83.6	84.8	73.6	63.4	64.4	72.6	74.5	66.2	67.3	61.8	86.8	85.2	74.0	77
Des Moines, Iowa	72.0	72.0	56.0	59.2	61.6	66.8	65.6	66.4	68.6	55.6	69.9	72.2	65.0	70
Springfield, Mo	75.8	77.2	66.1	59.6	69.4	74.2	84.2	81.0	77.4	57.7	74.2	78.0	73.0	73
Little Rock, Ark	71.0	70.0	64.2	62.2	70.2	75.1	81.3	76.6	72.0	65.2	77.8	76.0	72.0	73
Lincoln, Nebr	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Wichita, Kans	74.6	78.0	58.2	60.6	61.6	66.2	73.9	80.5	61.9	53.6	74.7	71.0	68.0	68
Palestine, Tex	73.5	76.9	68.4	65.2	80.2	84.1	82.8	78.2	72.0	66.8	78.2	70.6	75.0	73
Corpus Christi, Tex	87.0	83.2	87.3	77.1	85.6	83.6	85.5	84.4	83.2	78.0	85.4	78.6	83.0	82
Helena, Mont	71.0	67.8	62.9	46.6	47.2	49.7	42.5	39.0	49.1	55.5	62.6	65.9	55.0	55
Denver, Colo	57.0	60.8	53.6	42.8	45.8	51.2	55.8	52.2	37.8	53.4	44.9	41.4	50.0	49
Walla Walla, Wash	85.8	72.0	63.4	52.2	51.8	41.7	43.7	38.5	60.4	59.4	42.0	87.9	58.0	61
Sacramento, Cal	85.2	74.9	70.6	65.6	63.7	50.2	62.6	59.6	60.8	64.8	67.2	78.6	67.0	68
Los Angeles, Cal	76.0	69.1	76.8	73.7	76.2	73.0	79.5	79.8	67.6	81.8	59.6	57.4	73.0	72

NOTE.—Normals are for a period of eight years, except for Los Angeles and Wichita, which are for seven years.

THE WEATHER BUREAU AND ITS VOLUNTARY OBSERVERS.

For the information of persons who may be contemplating the offer of their services as voluntary observers to the Weather Bureau, the following statement concerning the equipment and duties of a voluntary observer has been prepared by the Chief of the Bureau:

When it is considered that of the more than 3,300 meteorological stations in the United States at which observations are being taken and recorded, about 2,900, or nearly 90 per cent, are voluntary, it will be realized to what extent those interested in meteorology are indebted to voluntary observers for the material supplied for scientific research. Without the cooperation of voluntary observers it would be wholly impracticable, with the data collected from the regular telegraphic stations of the Weather Bureau, to determine the local climatic features of the various sections of the country, which is being so thoroughly done through the extensive system of voluntary stations now in existence. The great increase in the number of voluntary meteorological stations during the past decade of years is due to the rapid extension of the State weather-service system, which now embraces the entire country in forty-two separate State weather-service organizations, which are auxiliaries of the national Weather Bureau in the collection of meteorological data, the distribution of the daily weather forecasts and special warnings, and in the collection and publication of local climatic and weather-crop information through monthly meteorological reports and weekly weather-crop bulletins.

For several years the national Weather Bureau has encouraged the establishment of voluntary meteorological stations by supplying to persons interested in meteorology an instrumental outfit consisting of standard self-registering thermometers and rain gauges, a book of instructions to observers, and suitable blank forms for recording observations, upon condition that one observation shall be taken daily, preferably about sunset or thereafter, and that copies of records of observations made be supplied to the Weather Bureau through the State weather service in whose territory the station is located. Owing to the limited supply of instruments available for distribution to voluntary observers, it has been necessary to impose certain restrictions in their issue in order that the instruments might be placed where observations would prove of the greatest value. It frequently happens that a person offers to cooperate as a voluntary observer and applies for instruments, and then learns through the Weather Bureau that a record is already being kept in his immediate vicinity. In such cases the Weather Bureau is compelled to decline the proffered services as observer as well as to

furnish the necessary instruments. Until a few years ago the Weather Bureau in providing instruments for new stations observed the general rule of equipping no station within 50 miles of one already established. With the gradual increase in the number of stations, this distance limit has been reduced to 25 or 30 miles. Persons occupying eligible locations under the rules now governing the issue of instruments, and willing to comply with the conditions upon which they are furnished, will, as far as practicable, be supplied with the instrumental outfit before mentioned upon application to either the Chief of the Weather Bureau, Washington, D. C., or the director of the State weather service in whose territory he resides.

The duties of a voluntary observer consist in taking and recording daily observations of temperature, rainfall, state of weather, and miscellaneous meteorological phenomena such as the occurrence of frosts, local storms, etc.

Observations of air pressure and wind velocity by voluntary observers are not desired by the Weather Bureau. Enough data of this nature for the purposes of the Bureau, in the forecasting of weather, are obtained from the regular, paid meteorological stations, from which daily telegraphic reports are received. Observations of air pressure by voluntary observers are mainly of interest to the observers themselves at the time of the observation in estimating the location of storm centers in vicinities where there is no access to the daily weather map issued by the Weather Bureau.

A trustworthy record of the weather is always of interest to any community, and is often of very great practical value. It is one of the objects of the Weather Bureau to foster and encourage the keeping of such records. There are numerous calls for records of the weather, as evidence in courts in important law cases, months, and even years, after the record is made. Contractors and others interested in outside work often want a record of days when there was rain or high winds, when streams were frozen over or swollen with floods, etc. Farmers are interested in the state of the season, whether forward or backward, as regards temperature and rainfall.

The Monthly Weather Review and other publications of the Weather Bureau are sent to voluntary observers in exchange for their observations, together with the weekly Weather Crop Bulletin and monthly reports of State weather services.

TEXTURE OF SOME TYPICAL SOILS.

No.	Locality.	Description.	Organic matter, water, and loss.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
472	Marley, Md	Truck	0.30	0.49	4.96	40.19	27.59	12.10	7.74	2.23	4.40
141	Davidsonville, Md	Wheat	5.25	.00	.23	1.71	6.08	30.82	20.92	11.21	23.78
937	Hagerstown, Md	Grass	12.88	.00	.08	.13	.53	10.94	19.02	4.67	51.75
16	Lititz, Pa	Cigar wrapper, Habana type	6.85	.06	.40	.93	3.11	11.45	30.55	10.35	36.30
1254	Poquonock, Conn.	Cigar wrapper, Sumatra type.	2.13	3.22	7.53	19.63	23.76	34.50	5.92	.78	2.53
759	Granville Co., N. C.	Bright tobacco	2.12	3.09	7.16	21.74	22.92	16.76	13.17	8.24	4.80
652	Lynchburg, Va	Shipping tobacco	9.88	.35	1.37	5.72	14.73	10.79	6.70	4.62	45.84
1317	Virginia City, Ill.	Upland loess	5.71	.00	.00	.00	.01	7.68	61.85	9.60	15.15
1803	Ogallala, Nebr	Plains marl	2.98	.00	.00	.03	1.95	76.58	12.93	1.31	4.22

NOTE.—The first three samples in the table represent the texture of typical soils of the Atlantic Coast States adapted to truck, wheat, and grass. Their agricultural value and adaptation to crops are largely dependent upon the relative proportion of the different grades of sand and clay, as this determines the relation of the soils to water. Soils differ greatly, however, in structure or in the arrangement of the soil grains, and as this changes their relation to water the texture is not always a guide to their agricultural value. The texture, together with a record of the moisture content, indicates very clearly the class of crops to which these soils are adapted. The same remarks apply to the four types of tobacco soil shown in the table. The loess soils are characterized by a large content of silt. These likewise differ in structure, and this affects their agricultural value. The plains marl of western Kansas and Nebraska is characterized by a large percentage of very fine sand.

The following table gives the weight of a cubic foot of soil under different degrees of compactness, together with the amount of space in these soils, and the per cent of water in the saturated soil when all the space is filled with water:

Per cent by volume of space.	Weight of 1 cubic foot of water-free soil (pounds).	Water in 1 cubic foot of saturated soil (pounds).	Weight of 1 cubic foot of soil, when saturated (pounds).	Per cent by weight of water in saturated soil.
35	107.5	21.8	129.3	16.9
40	99.2	25.0	124.2	20.1
45	90.6	28.1	118.7	22.4
50	82.7	31.2	113.9	27.4
55	74.4	34.3	108.7	31.5
60	66.2	37.4	103.6	36.1
65	58.1	40.6	88.7	41.2

The specific gravity of upland arable soils varies but little and may be assumed to be about 2.65 to 2.70; *the former is used by the Department of Agriculture for* the mineral constituents of arable soils. The amount of space, therefore, in a cubic foot of such soil is determined by the compactness, or close arrangement, of the soil grains. As a rule, coarse, sandy soils are the most compact and contain the least amount of intergranular space, rarely containing less than 35 per cent of space, however. The amount of space appears larger, as the grains are large and each individual space is larger, but the aggregate amount of space is less. Clay soils usually contain considerably more space than sandy soils, going as high as 60 or 65 per cent in common arable clay lands. The weight of a cubic foot of dry soil in its natural condition is given approximately in the second column for several conditions of compactness. The weight of water contained in the soil, if all the space is completely filled with it, is given in the third column. Arable soils in good condition for crops rarely contain more than from 30 to 60 per cent of the saturating quantity. The total weight of a cubic foot of saturated soil and the percentages are given in the fourth and fifth columns.

EDUCATIONAL INSTITUTIONS IN THE UNITED STATES HAVING COURSES IN AGRICULTURE.

State.	Name of institution.	Locality.	President.
Alabama	Agricultural and Mechanical College	Auburn	W. L. Broun.
Arizona	University of Arizona	Tucson	Howard Billman.
Arkansas	Arkansas Industrial University	Fayetteville	J. L. Buchanan.
California	College of Agr'ture of the University	Berkeley	M. Kellogg.
Colorado	The State Agricultural College	Fort Collins	Alston Ellis.
Connecticut	Storrs Agricultural College	Storrs	B. F. Koons.
	Sheffield Scientific School of Yale University.	New Haven	Timothy Dwight.
Delaware	Delaware College	Newark	A. N. Raub.
	State College for Colored Students	Dover	W. C. Jason.
Florida	State Agricultural and Mech. College	Lake City	O. Clute.
	Florida State Normal School	Tallahassee	T. DeS. Tucker.
Georgia	College of Agr'ture and Mech. Arts	Athens	H. C. White.
Idaho	College of Agr'ture of the University	Moscow	F. B. Gault.
Illinois	College of Agr'ture of the University	Urbana	A. S. Draper.
Indiana	School of Agriculture, Horticulture, and Veterinary Science of Purdue University.	Lafayette	J. H. Smart.
Iowa	College of Agr'ture and Mech. Arts	Ames	W. M. Beardshear.
Kansas	Kansas State Agricultural College	Manhattan	Geo. T. Fairchild.
Kentucky	Agricultural and Mechanical College	Lexington	J. K. Patterson.
	State Normal School	Frankfort	J. H. Jackson.
Louisiana	State University and Agricultural and Mechanical College.	Baton Rouge	J. W. Nicholson.
	Southern University and Agricultural and Mechanical College.	New Orleans	H. A. Hill.
Maine	The Maine State College	Orono	A. W. Harris.
Maryland	Maryland Agricultural College	College Park	R. W. Silvester.
Massachusetts	Massachusetts Agricultural College	Amherst	H. H. Goodell.
Michigan	Michigan Agricultural College	Agricultural College.	J. L. Snyder.
Minnesota	College of Agriculture of the Univ.	Minneapolis	Cyrus Northrop.
Mississippi	Agricultural and Mechanical College	Agricultural College.	S. D. Lee.
	Alcorn Agr'tural and Mech. College	Westside	T. J. Calloway.

EDUCATIONAL INSTITUTIONS IN THE UNITED STATES HAVING COURSES IN AGRICULTURE—Continued.

State.	Name of institution.	Locality.	President.
Missouri	College of Agriculture and Mechanic Arts of the University.	Columbia	Richard H. Jesse.
Montana	College of Agr'ture and Mech. Arts	Bozeman	James Reid.
Nebraska	Industrial College of the University	Lincoln	G. E. MacLean.
Nevada	School of Agriculture of University	Reno	J. E. Stubbs.
New Hampshire	College of Agriculture and the Mechanic Arts.	Durham	C. S. Murkland.
New Jersey	Rutgers Scientific School	New Brunswick	Austin Scott.
New Mexico	College of Agr'ture and Mech. Arts	Mesilla Park	S. P. McCrea.
New York	Cornell University	Ithaca	J. G. Schurman.
North Carolina	College of Agr'ture and Mech. Arts	Raleigh	A. Q. Holliday.
North Dakota	North Dakota Agricultural College	Fargo	J. H. Worst.
Ohio	Ohio State University	Columbus	J. H. Canfield.
Oklahoma	Agr'tural and Mechanical College	Stillwater	G. E. Morrow.
Oregon	Oregon State Agricultural College	Corvallis	John M. Bloss.
Pennsylvania	Pennsylvania State College	State College	George W. Atherton.
Rhode Island	College of Agr'ture and Mech. Arts	Kingston	J. H. Washburn.
South Carolina	Clemson Agricultural College	Clemson College	E. B. Craighead.
	College of Agr'ture and Mechanics' Institute of Claflin University.	Orangeburg	L. M. Dunton.
South Dakota	South Dakota Agricultural College	Brookings	L. McLouth.
Tennessee	State Agr'tural and Mech. College	Knoxville	C. W. Dabney, jr.
Texas	State Agr'tural and Mech. College	College Station	L. S. Ross.
	Prairie View State Normal School	Prairie View	L. C. Anderson.
Utah	Agricultural College of Utah	Logan	Joshua H. Paul.
Vermont	State Agricultural College of the University.	Burlington	M. H. Buckham.
Virginia	Agr'tural and Mechanical College	Blacksburg	J. M. McBryde.
	Hampton Normal and Agricultural Institute.	Hampton	H. B. Frissell.
Washington	Agric. College and School of Science	Pullman	E. A. Bryan.
West Virginia	West Virginia University	Morgantown	J. L. Goodknight.
	The West Virginia Colored Institute	Farm	J. H. Hill.
Wisconsin	College of Agr'ture of the University	Madison	C. K. Adams.
Wyoming	College of Agr'ture of the University	Laramie	A. A. Johnson.

AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES, THEIR LOCATION, DIRECTORS, AND PRINCIPAL LINES OF WORK.

Station.	Director.	Lines of work in addition to chemistry, horticulture, and field experiments.
Alabama (College), Auburn	W. L. Broun	Meteorology; botany; diseases of plants.
Alabama (Canebrake), Uniontown.	H. Benton	Diseases of animals.
Arizona, Tucson	W. S. Devol	Entomology; forestry; irrigation.
Arkansas, Fayetteville	R. L. Bennett	Analysis of fertilizers and feeding stuffs; entomology; diseases of plants; diseases of animals.
California, Berkeley	E. W. Hilgard	Meteorology; physics and chemistry of soils; composition and cultivation of grapes and orchard fruits (especially olives); composition of feeding stuffs; entomology; technology, drainage, and irrigation; reclamation of alkali lands.
Colorado, Fort Collins	Alston Ellis	Meteorology; botany; entomology; irrigation.
Connecticut (State), New Haven	S. W. Johnson	Analysis and inspection of fertilizers; chemistry of feeding stuffs; chemistry of milk and its products; diseases of plants; pot experiments with organic nitrogen.
Connecticut (Storrs), Storrs	W. O. Atwater	Chemistry of feeding stuffs and food of man; digestion experiments; dietary studies; bacteriology of milk and its products; dairying.
Delaware, Newark	A. T. Neale	Diseases of plants; entomology; feeding experiments; dairying; diseases of animals.
Florida, Lake City	O. Clute	
Georgia, Experiment	R. J. Redding	Dairying.
Idaho, Moscow	C. P. Fox	Botany; soils and water; feeding experiments (pigs); drainage and irrigation.
Illinois, Urbana	T. J. Burrill	Bacteriology; forestry; diseases of plants; entomology; feeding experiments; dairying.

AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES, THEIR LOCATION, DIRECTORS, ETC.—Continued.

Station.	Director.	Lines of work in addition to chemistry, horticulture, and field experiments.
Indiana, Lafayette	C. S. Plumb	Pot and field experiments; feeding experiments (cows and sheep); diseases of animals.
Iowa, Ames	James Wilson	Diseases of plants; entomology; feeding experiments; dairying.
Kansas, Manhattan	G. T. Fairchild	Diseases of plants; entomology; feeding experiments; diseases of animals; irrigation.
Kentucky, Lexington	M. A. Scovell	Soils; fertilizer analysis; diseases of plants; entomology; dairying.
Louisiana (Sugar), New Orleans.	W. C. Stubbs	Soils; sugar making; drainage and irrigation.
Louisiana (State), Baton Rouge.	do	Geology; soils; diseases of plants; entomology; diseases of animals.
Louisiana (North), Calhoun	do	Feeding experiments.
Maine, Orono	W. H. Jordan	Diseases of plants; digestion and feeding experiments; diseases of animals; dairying.
Maryland, College Park	R. H. Miller	Soils; entomology; feeding experiments; drainage.
Massachusetts (Hatch), Amherst.	H. H. Godell	Analysis and control of fertilizers; digestion and feeding experiments; meteorology; diseases of plants; entomology; diseases of animals.
Michigan, Agricultural College.	C. D. Smith	Botany; soils; diseases of plants; entomology; feeding experiments; diseases of animals; dairying; irrigation.
Minnesota, St. Anthony Park	W. M. Liggett	Chemistry of foods; soils; weeds; entomology; feeding and breeding experiments; diseases of animals; dairying.
Mississippi, Agricultural College.	S. M. Tracy	Botany; soils; entomology; digestion and feeding experiments; diseases of animals; drainage and irrigation.
Missouri, Columbia	P. Schweitzer	Diseases of plants; entomology; feeding experiments; drainage.
Montana, Bozeman	S. M. Emery	Diseases of plants; feeding experiments; diseases of animals; irrigation.
Nebraska, Lincoln	G. E. MacLean	Botany; meteorology; forestry; feeding and breeding experiments; diseases of animals.
Nevada, Reno	J. E. Stubbs	Botany; soils; entomology; irrigation.
New Hampshire, Durham	C. S. Murkland	Feeding experiments; diseases of animals; dairying.
New Jersey (State), New Brunswick.	E. B. Voorhees	Analysis and control of fertilizers; horticulture.
New Jersey (College), New Brunswick.	do	Botany; diseases of plants; entomology; diseases of animals.
New Mexico, Mesilla Park	S. P. McCrea	Botany; diseases of plants; entomology; feeding experiments.
New York (State), Geneva	L. L. Van Slyke	Meteorology; analysis and control of fertilizers; diseases of plants; feeding experiments; poultry experiments; dairying.
New York (Cornell), Ithaca	I. P. Roberts	Fertilizer investigations; diseases of plants; entomology; feeding experiments; poultry experiments; dairying.
North Carolina, Raleigh	H. B. Battle	Meteorology; analysis and control of fertilizers; seed testing; composition of feeding stuffs.
North Dakota, Fargo	J. H. Worst	Diseases of plants; feeding experiments.
Ohio, Wooster	C. E. Thorne	Soils; diseases of plants; entomology; breeding and feeding experiments.
Oklahoma, Stillwater	G. E. Morrow	Soils and waters; feeding experiments; entomology.
Oregon, Corvallis	J. M. Bloss	Soils; diseases of plants; entomology; feeding experiments.
Pennslyvania, State College	H. P. Armsby	Meteorology; fertilizer analysis; feeding experiments; dairying.
Rhode Island, Kingston	C. O. Flagg	Pot experiments; diseases of plants; poultry experiments.
South Carolina, Clemson College.	E. B. Craighead	Soils; analysis and control of fertilizers.
South Dakota, Brookings	L. McLouth	Chemistry of waters; diseases of plants; dairying.
Tennessee, Knoxville	C. F. Vanderford.	Botany; entomology.
Texas, College Station	J. H. Connell	Diseases of plants; entomology; feeding experiments; diseases of animals.
Utah, Logan	J. H. Paul	Feeding experiments; diseases of animals; dairying; irrigation.
Vermont, Burlington	J. L. Hills	Analysis and control of fertilizers; diseases of plants; entomology; feeding experiments; diseases of animals; dairying.
Virginia, Blacksburg	J. M. McBryde	Diseases of plants; feeding experiments; diseases of animals; entomology.

AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES, THEIR LOCATION, DIRECTORS, ETC.—Continued.

Station.	Director.	Lines of work in addition to chemistry, horticulture, and field experiments.
Washington, Pullman	E. A. Bryan	Soils; forestry; feeding experiments.
West Virginia, Morgantown	J. A. Myers	Meteorology; analysis and control of fertilizers; entomology.
Wisconsin, Madison	W. A. Henry	Soils; feeding experiments (pigs and sheep); diseases of animals; dairying; drainage and irrigation.
Wyoming, Laramie	A. A. Johnson	Botany; waters; food analyses; irrigation.

FEEDING STUFFS (FOR ANIMALS).

EXPLANATIONS OF TERMS USED IN THE TABLE.

Water.—All feeding stuffs contain water. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorine, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is therefore stored up in the animal's body; the rest is voided in the manure.

Protein (or nitrogenous materials) is the name of a group of materials containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, and the casein and albumen of milk, etc., and is one of the most important constituents of feeding stuffs.

Fiber.—Fiber, sometimes called cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains. The nitrogen-free extract and fiber are usually classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy.

Fat, or the materials dissolved from a feeding stuff by ether, is an impure product, and includes, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

Average composition of American feeding stuffs.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
GREEN FODDER.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Corn fodder, all varieties	79.3	1.2	1.8	5.0	12.2	0.5
Rye fodder	76.6	1.8	2.6	11.6	6.8	.6
Oat fodder	62.2	2.5	3.4	11.2	19.3	1.4
Redtop (*Agrostis vulgaris*)[1] in bloom	65.3	2.3	2.8	11.0	17.7	.9
Tall oat grass (*Arrhenatherum avenaceum*)[2]	69.5	2.0	2.4	9.4	15.8	.9
Orchard grass (*Dactylis glomerata*)	73.0	2.0	2.6	8.2	13.3	.9
Meadow fescue (*Festuca pratensis*)	69.9	1.8	2.4	10.8	14.3	.8
Italian rye grass (*Lolium italicum*)	73.2	2.5	3.1	6.8	13.3	1.3
Timothy (*Phleum pratense*)[3]	61.6	2.1	3.1	11.8	20.2	1.2
Kentucky blue grass (*Poa pratensis*)[4]	65.1	2.8	4.1	9.1	17.6	1.3
Hungarian grass (*Setaria*)	71.1	1.7	3.1	9.2	14.2	.7
Red clover (*Trifolium pratense*)	70.8	2.1	4.4	8.1	13.5	1.1
Alsike clover (*Trifolium hybridum*)[5]	74.8	2.0	3.9	7.4	11.0	.9
Crimson clover (*Trifolium incarnatum*)	80.9	1.7	3.1	5.2	8.4	.7
Alfalfa (*Medicago sativa*)[6]	71.8	2.7	4.8	7.4	12.3	1.0
Serradella (*Ornithopus sativus*)	79.5	3.2	2.7	5.4	8.6	.7
Cowpea	83.6	1.7	2.4	4.8	7.1	.4
Soja bean (*Soja hispida*)	75.1	2.6	4.0	6.7	10.6	1.0
Horse bean (*Vicia faba*)	84.2	1.2	2.8	4.9	6.5	.4
Flat pea (*Lathyrus sylvestris*)	66.7	2.9	8.7	7.9	12.2	1.6
Rape	84.5	2.0	2.3	2.6	8.4	.5

[1] Herd's grass of Pennsylvania.
[2] Meadow oat grass.
[3] Herd's grass of New England and New York.
[4] June grass.
[5] Swedish clover.
[6] Lucern.

Average composition of American feeding stuffs—Continued.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
SILAGE.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Corn silage	79.1	1.4	1.7	6.0	11.0	.8
Red-clover silage	72.0	2.6	4.2	8.4	11.6	1.2
Soja-bean silage	74.2	2.8	4.1	9.7	6.9	2.2
Cowpea-vine silage	79.3	2.9	2.7	6.0	7.6	1.5
HAY AND DRY COARSE FODDER.						
Corn fodder,[1] field cured	42.2	2.7	4.5	14.3	34.7	1.6
Corn leaves, field cured	30.0	5.5	6.0	21.4	35.7	1.4
Corn husks, field cured	50.9	1.8	2.5	15.8	28.3	.7
Corn stover,[2] field cured	40.5	3.4	3.8	19.7	31.5	1.1
Hay from—						
Redtop	8.9	5.2	7.9	28.6	47.5	1.9
Orchard grass	9.9	6.0	8.1	32.4	41.0	2.6
Timothy	13.2	4.4	5.9	29.0	45.0	2.5
Kentucky blue grass	21.2	6.3	7.8	23.0	37.8	3.9
Hungarian grass	7.7	6.0	7.5	27.7	49.0	2.1
Meadow fescue	20.0	6.8	7.0	25.9	38.4	2.7
Italian rye grass	8.5	6.9	7.5	30.5	45.0	1.7
Mixed grasses	15.3	5.5	7.4	27.2	42.1	2.5
Rowen (mixed)[3]	16.6	6.8	11.6	22.5	39.4	3.1
Mixed grasses and clovers	12.9	5.5	10.1	27.6	41.3	2.6
Red clover	15.3	6.2	12.3	24.8	38.1	3.3
Alsike clover	9.7	8.3	12.8	25.6	40.7	2.9
White clover (*Trifolium repens*)	9.7	8.3	15.7	24.1	39.3	2.9
Crimson clover	9.6	8.6	15.2	27.2	36.6	2.8
Japan clover (*Lespedeza striata*)	11.0	8.5	13.8	24.0	39.0	3.7
Vetch	11.3	7.9	17.0	25.4	36.1	2.3
Serradella	9.2	7.2	15.2	21.6	44.2	6.2
Alfalfa[4]	8.4	7.4	14.3	25.0	42.7	2.2
Cowpea	10.7	7.5	16.6	20.1	42.2	2.2
Soja bean	11.3	7.2	15.4	22.3	38.6	5.2
Flat pea	8.4	7.9	22.9	26.2	31.4	3.2
Peanut vines (without nuts)	7.6	10.8	10.7	23.6	42.7	4.6
Soja-bean straw	10.1	5.8	4.6	40.4	37.4	1.7
Horse-bean straw	9.2	8.7	8.8	37.6	34.3	1.4
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3
Buckwheat straw	9.9	5.5	5.2	43.0	35.1	1.3
ROOTS AND TUBERS.						
Sugar beets	86.5	.9	1.8	.9	9.8	.1
Mangel-wurzels	90.9	1.1	1.4	.9	5.5	.2
Ruta-bagas	88.6	1.2	1.2	1.3	7.5	.2
Carrots	88.6	1.0	1.1	1.3	7.6	.4
Artichokes	79.5	1.0	2.6	.8	15.9	.2
GRAINS AND OTHER SEEDS.						
Corn, kernels	10.9	1.5	10.5	2.1	69.6	5.4
Barley	10.9	2.4	12.4	2.7	69.8	1.8
Oats	11.0	3.0	11.8	9.5	59.7	5.0
Rye	11.6	1.9	10.6	1.7	72.5	1.7
Wheat	10.5	1.8	11.9	1.8	71.9	2.1
Sunflower seed (whole)	8.6	2.6	16.3	29.9	21.4	21.2
Cotton seed (whole, with hulls)	10.3	3.5	18.4	23.2	24.7	19.9
Peanut kernels (without hulls)	7.5	2.4	27.9	7.0	15.6	39.6
Horse bean	11.3	3.8	26.6	7.2	50.1	1.0
Soja bean	10.8	4.7	34.0	4.8	28.8	16.9
Cowpea	14.8	3.2	20.8	4.1	55.7	1.4
MILL PRODUCTS.						
Corn meal	15.0	1.4	9.2	1.9	68.7	3.8
Corn and cob meal	15.1	1.5	8.5	6.6	64.8	3.5
Oatmeal	7.9	2.0	14.7	.9	67.4	7.1
Barley meal	11.9	2.6	10.5	6.5	66.3	2.2
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2
WASTE PRODUCTS.						
Oat feed, average	7.7	3.7	16.0	6.1	59.4	7.1
Barley screenings, average	12.2	3.6	12.3	7.3	61.8	2.8
Malt sprouts, average	10.2	5.7	23.2	10.7	48.5	1.7
Brewers' grains (wet)	75.7	1.0	5.4	3.8	12.5	1.6

[1] Entire plant.
[2] What is left after the ears are harvested.
[3] Second cut of hay.
[4] Lucern.

Average composition of American feeding stuffs—Continued.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
WASTE PRODUCTS—continued.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Brewers' grains (dried)	8.2	3.6	19.9	11.0	51.7	5.6
Rye bran	11.6	3.6	14.7	3.5	63.8	2.8
Wheat bran	11.9	5.8	15.4	9.0	53.9	4.0
Wheat middlings	12.1	3.3	15.6	4.6	60.4	4.0
Wheat shorts	11.8	4.6	14.9	7.4	56.8	4.5
Wheat screenings	11.6	2.9	12.5	4.9	65.1	3.0
Rice bran	9.7	10.0	12.1	9.5	49.9	8.8
Rice hulls	8.2	13.2	3.6	35.7	38.6	.7
Rice polish	10.0	6.7	11.7	6.3	58.0	7.3
Buckwheat middlings	13.2	4.8	28.9	4.1	41.9	7.1
Cotton-seed meal	8.2	7.2	42.3	5.6	23.6	13.1
Cotton-seed hulls	11.1	2.8	4.2	46.3	33.4	2.2
Linseed meal (old process)	9.2	5.7	32.9	8.9	35.4	7.9
Linseed meal (new process)	10.1	5.8	33.2	9.5	38.4	3.0
Peanut meal	10.7	4.9	47.6	5.1	23.7	8.0
Peanut hulls	9.0	3.4	6.6	64.3	15.1	1.6
Hominy chops	11.1	2.5	9.8	3.8	64.5	8.3
Refuse from cornstarch factories.						
Corn germ	10.7	4.0	9.8	4.1	64.0	7.4
Corn-germ meal	8.1	1.3	11.1	9.9	62.5	7.1
Gluten meal:						
Early analyses	8.8	.8	29.7	2.2	49.8	8.7
Recent analyses	8.2	.9	29.3	3.3	46.5	11.8
Chicago	10.1	1.1	30.1	1.6	48.7	8.4
Buffalo	8.2	.8	23.3	6.1	50.4	11.2
Cream gluten	8.1	.7	36.1	1.3	39.0	14.8
Gluten feed	7.8	1.1	24.0	5.3	51.2	10.6
Chicago maize feed	9.1	.9	22.8	7.6	52.7	6.9
Glucose feed and glucose refuse	6.5	1.1	20.7	4.5	56.8	10.4
Dried-starch feed and sugar feed	10.9	.9	19.7	4.7	54.8	9.0
Starch feed (wet)	65.4	.3	6.1	3.1	22.0	3.1

DIGESTIBILITY OF FEEDING STUFFS.

The preceding tables give the total amounts of nutrients found by analysis in different feeding stuffs. Only a portion of these amounts is of direct use to the animal, i. e., that digested. The rest passes through the animal and is excreted as manure. The amounts of the different food constituents of feeding stuffs digested have been determined by careful experiments on different classes of animals. The results thus obtained in American experiments have been used in calculating the amounts of digestible protein, fat, and carbohydrates contained in 100 pounds of different feeding stuffs shown in the table below. These are the figures which must be consulted in determining the food value of a given material and in selecting feeding stuffs for making up a ration.

Calorie.—The last column of the table, headed "fuel value," indicates the value of the food for producing heat for the body and energy for the work. It is stated in calories, a calorie being the amount of heat required to raise the temperature of a pound of water 4° F.

Dry matter and digestible food ingredients in 100 pounds of feeding stuffs.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Green fodder:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Corn fodder [1]	20.7	1.10	12.08	0.37	26,076
Rye fodder	23.4	2.05	14.11	.44	31,914
Oat fodder	37.8	2.69	22.66	1.04	51,624
Redtop, in bloom	34.7	2.06	21.24	.58	45,785
Orchard grass, in bloom	27.0	1.91	15.91	.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	.42	34,755
Timothy [2]	38.4	2.28	23.71	.77	51,591
Kentucky blue grass	34.9	3.01	19.83	.83	45,985
Hungarian grass	28.9	1.92	15.63	.36	34,162
Red clover	29.2	3.07	14.82	.69	36,187
Crimson clover	19.3	2.16	9.31	.44	23,191
Alfalfa [3]	28.2	3.89	11.20	.41	29,798
Cowpea	16.4	1.68	8.08	.25	19,209
Soja bean	28.5	2.79	11.82	.63	29,833

[1] Corn fodder is entire plant, usually sown thick. [2] Herd's grass of New England and New York. [3] Lucern.

Dry matter and digestible food ingredients in 100 pounds of feeding stuffs—Cont'd.

Feeding stuff.	Dry matter.	Protein.	Carbo-hydrates.	Fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Corn silage	20.9	.56	11.79	.65	25,714
Corn fodder,[1] field cured	57.8	2.48	33.38	1.15	71,554
Corn stover, field cured	59.5	1.98	33.16	.57	67,766
Hay from—					
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	.95	100,078
Timothy[2]	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.33	1.95	86,516
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80.0	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Rowen (mixed)	83.4	7.19	41.20	1.43	96,040
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	6.58	35.35	1.66	84,995
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95,877
Alfalfa[3]	91.6	10.58	37.33	1.38	94,936
Cowpea	89.3	10.79	38.40	1.51	97,865
Soja bean	88.7	10.78	38.72	1.54	98,568
Wheat straw	90.4	.80	37.94	.46	73,998
Rye straw	92.9	.74	42.71	.35	82,294
Oat straw	90.8	1.58	41.63	.74	83,493
Soja-bean straw	89.9	2.30	39.98	1.03	82,987
Roots and tubers:					
Potatoes	21.1	1.27	15.59	....	31,360
Beets	13.0	1.21	8.84	.05	18,904
Mangel-wurzels	9.1	1.03	5.65	.11	12,888
Turnips	9.5	.81	6.46	.11	13,986
Ruta-bagas	11.4	.88	7.74	.11	16,497
Carrots	11.4	.81	7.83	.22	16,999
Grains and other seeds:					
Corn (dent and flint)	89.1	7.92	66.69	4.28	156,836
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89.0	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat	89.5	10.23	69.21	1.68	154,848
Cotton seed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85.0	7.01	65.20	3.25	148,026
Corn-and-cob meal	84.9	6.46	56.28	2.87	128,808
Oatmeal	92.1	11.53	52.06	5.93	143,302
Barley meal	88.1	7.36	62.88	1.96	138,818
Ground corn and oats, equal parts	88.1	7.39	61.20	3.72	143.276
Pea meal	89.5	16.77	51.78	.65	130,246
Waste products:					
Gluten feed	92.2	20.40	43.75	8.59	155,569
Gluten meal	91.2	25.49	42.32	10.38	169,930
Hominy chops	88.9	7.45	55.24	6.81	145,342
Malt sprouts	89.8	18.72	43.50	1.16	120,624
Brewers' grains (wet)	24.3	4.00	9.37	1.38	30,692
Brewers' grains (dried)	91.1	14.73	36.60	4.82	115,814
Rye bran	88.4	11.45	50.28	1.96	123,089
Wheat bran	88.5	12.01	41.23	2.87	111,138
Wheat middlings	84.0	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Buckwheat middlings	86.8	17.34	26.58	4.54	100,850
Cotton-seed meal	91.8	37.01	16.52	12.58	152,653
Cotton-seed hulls	88.9	.42	30.95	1.69	65,480
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	89.8	27.89	36.36	2.73	131,026
Peanut meal	89.3	42.94	22.82	6.86	151,263
Milk and its by-products:					
Whole milk	12.8	3.48	4.77	3.70	30,866
Skim milk—					
Cream raised by setting	9.6	3.13	4.69	.83	18,048
Cream raised by separator	9.4	2.94	5.24	.29	16,439
Buttermilk	9.9	3.87	4.00	1.06	37,685
Whey	6.6	.84	4.74	.31	11,687

[1] Corn fodder is entire plant, usually sown thick. [2] Herd's grass of New England and New York. [3] Lucern.

FEEDING STANDARDS.

Attempts have been made to ascertain the food requirements of various kinds of farm animals under different conditions. From the results of experiments feeding standards have been worked out which show the amounts of digestible protein, fat, and carbohydrates supposed to be best adapted to different animals

when kept for different purposes. The feeding standards of Wolff, a German, have been most widely used. They are as follows:

Wolff's feeding standards.

A.—PER DAY AND PER 1,000 POUNDS LIVE WEIGHT.

Kind of animal.	Total organic matter.	Digestible food materials.			Fuel value.
		Protein.	Carbohydrates.	Fat.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Oxen at rest in stall	17.5	0.7	8.0	0.15	16,815
Wool sheep, coarser breeds	20.0	1.2	10.3	.20	22,235
Wool sheep, finer breeds	22.5	1.5	11.4	.25	25,050
Oxen moderately worked	24.0	1.6	11.3	.30	24,260
Oxen heavily worked	26.0	2.4	13.2	.50	31,126
Horses moderately worked	22.5	1.8	11.2	.60	26,712
Horses heavily worked	25.5	2.8	13.4	.80	33,508
Milch cows	24.0	2.5	12.5	.40	29,590
Fattening steers:					
First period	27.0	2.5	15.0	.50	34,660
Second period	26.0	3.0	14.8	.70	36,062
Third period	25.0	2.7	14.8	.60	35,082
Fattening sheep:					
First period	26.0	3.0	15.2	.50	35,962
Second period	25.0	3.5	14.4	.60	35,826
Fattening swine:					
First period	36.0	5.0	27.5		69,450
Second period	31.0	4.0	24.0		52,080
Third period	23.5	2.7	17.5		37,570

B.—PER DAY AND PER HEAD.

Kind of animal.	Average live weight per head.	Total organic matter.	Digestible food materials.			Fuel value.
			Protein.	Carbohydrates.	Fat.	
Growing cattle:						
Age—	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
2 to 3 months	150	3.3	0.6	2.1	0.30	5,116
3 to 6 months	300	7.0	1.0	4.1	.30	10,750
6 to 12 months	500	12.0	1.3	6.8	.30	16,332
12 to 18 months	700	16.8	1.4	9.1	.28	20,712
18 to 24 months	850	20.4	1.4	10.3	.26	22,859
Growing sheep:						
Age—						
5 to 6 months	56	1.6	.18	.87	.045	2,143
6 to 8 months	67	1.7	.17	.85	.040	2,066
8 to 11 months	75	1.7	.16	.85	.037	2,035
11 to 15 months	82	1.8	.14	.89	.032	2,051
15 to 20 months	85	1.9	.12	.88	.025	1,966
Growing fat swine:						
Age—						
2 to 3 months	50	2.1	.38	1.50		3,496
3 to 5 months	100	3.4	.50	2.50		5,580
5 to 6 months	125	3.9	.54	2.96		6,510
6 to 8 months	170	4.6	.58	3.47		7,533
8 to 12 months	250	5.2	.62	4.05		8,686

CALCULATION OF RATIONS.

In order to explain the use of the preceding tables, let us calculate the daily ration for a cow, assuming that the farmer has on hand clover hay, corn silage, corn meal, and wheat bran. Wolff's standard for a cow of 1,000 pounds calls for 2.5 pounds of protein, 12.5 pounds of carbohydrates, and 0.4 pound of fat, which would furnish 29,590 calories of heat. From the table showing the amounts of digestible nutrients we find that 100 pounds of clover hay furnishes 84.7 pounds of dry matter, 6.58 pounds of protein, 35.35 pounds of carbohydrates, and 1.66 pounds of fat, equivalent to a fuel value of 84,995 calories. Twelve pounds would have 10.16 pounds of dry matter, 0.79 pound of protein, 4.24 pounds of carbohydrates, and 0.20 pound of fat, giving a fuel value of 10,199 calories.

In the same way the amounts furnished by 20 pounds of corn silage, 4 pounds of corn meal, and 4 pounds of wheat bran are found. The result would be the following table:

Method of calculating ration for dairy cow.

Ration.	Total dry matter.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
12 pounds of clover hay	10.16	0.79	4.24	0.20	10,199
20 pounds of corn silage	4.18	.11	2.36	.13	5,143
4 pounds of corn meal	3.40	.28	2.61	.13	5,921
4 pounds of wheat bran	3.54	.48	1.65	.11	4,446
Total	21.28	1.66	10.86	.57	25,709
Wolff's standard	24.00	2.50	12.50	.40	29,590

This ration is below the standard, especially in protein. To furnish the protein needed, without increasing the other nutrients too much, a feeding stuff quite rich in protein is needed. The addition of 4 pounds of gluten feed would make the ration contain:

Completed ration for dairy cow.

Ration.	Total dry matter.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
12 pounds clover hay, 20 pounds corn silage, 4 pounds corn meal, and 4 pounds wheat bran	21.28	1.66	10.86	0.57	25,709
4 pounds gluten feed	3.69	.82	1.75	.34	6,223
Total	24.97	2.48	12.61	.91	31,932

This ration, it will be seen, contains somewhat more carbohydrates and fat than the standard calls for, but is close enough to the standard for practical purposes. The calculation may be considerably simplified, without impairing accuracy, by considering only the protein and the fuel value. For example, suppose the farmer feeds his cows dry corn fodder (not stover), good timothy hay (herd's grass), and a grain mixture composed of equal parts of corn meal, wheat bran, and gluten meal, a ration might be made from these as follows:

Ration per cow daily.

Ration.	Dry matter.	Protein.	Fuel value.
	Pounds.	*Pounds.*	*Calories.*
10 pounds timothy hay	8.68	0.30	9,273
10 pounds dry corn fodder	5.78	.25	7,155
4 pounds corn meal	3.40	.28	5,921
4 pounds wheat bran	3.54	.48	4,446
4 pounds gluten meal	3.62	1.02	6,797
Total	25.02	2.33	33,592

This ration is higher than the standard in fuel value, owing to richness of the materials in carbohydrates and fat, and slightly lower in protein. The substitution of 1 pound of new-process linseed meal in place of 1 pound of the corn meal would give 0.21 pound more protein, which would make the ration contain 2.54 pounds of protein.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
GREEN FODDERS.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Corn fodder	78.61	4.84	0.41	0.15	0.33
Sorghum fodder	82.19	....	.23	.09	.23
Rye fodder	62.11	....	.33	.15	.73
Oat fodder	83.36	1.31	.49	.13	.38
Common millet	62.58	....	.61	.19	.41
Japanese millet	71.05	....	.53	.20	.34
Hungarian grass (*Setaria*)	74.31	....	.39	.16	.55
Orchard grass (*Dactylis glomerata*)[1]	73.14	2.09	.43	.16	.76
Timothy grass (*Phleum pratense*)[1]	66.90	2.15	.48	.26	.76
Perennial rye grass (*Lolium perenne*)[1]	75.20	2.60	.47	.28	1.10
Italian rye grass (*Lolium italicum*)[1]	74.85	2.84	.54	.29	1.14
Mixed pasture grasses	63.12	3.27	.91	.23	.75
Red clover (*Trifolium pratense*)	80.00	....	.53	.13	.46
White clover (*Trifolium repens*)	81.00	....	.56	.20	.24
Alsike clover (*Trifolium hybridum*)	81.80	1.47	.44	.11	.20
Crimson clover (*Trifolium incarnatum*)	82.50	....	.43	.13	.49
Alfalfa (*Medicago sativa*)	75.30	2.25	.72	.13	.56
Cowpea	78.81	1.47	.27	.10	.31
Serradella (*Ornithopus sativus*)	82.59	1.82	.41	.14	.42
Soja bean (*Soja hispida*)	73.20	....	.29	.15	.53
Horse bean (*Vicia faba*)	74.71	....	.68	.33	1.37
White lupine (*Lupinus albus*)	85.35	....	.44	.35	1.73
Yellow lupine (*Lupinus luteus*)[1]	83.15	.96	.51	.11	.15
Flat pea (*Lathyrus sylvestris*)[1]	71.60	1.93	1.13	.18	.58
Common vetch (*Vicia sativa*)[1]	84.50	1.94	.59	1.19	.70
Prickly comfrey (*Symphytum asperrimum*)	84.36	2.45	.42	.11	.75
Corn silage	77.95	....	.28	.11	.37
Apple pomace silage[1]	75.00	1.05	.32	.15	.40
HAY AND DRY COARSE FODDERS.					
Corn fodder (with ears)	7.85	4.91	1.76	.54	.89
Corn stover (without ears)	9.12	3.74	1.04	.29	1.40
Teosinte (*Euchlæna luxurians*)	6.06	6.53	1.46	.55	3.70
Common millet	9.75	....	1.28	.49	1.69
Japanese millet	10.45	5.80	1.11	.40	1.22
Hungarian grass	7.69	6.18	1.20	.35	1.30
Hay of mixed grasses	11.99	6.34	1.41	.27	1.55
Rowen of mixed grasses	18.52	9.57	1.61	.43	1.49
Redtop (*Agrostis vulgaris*)	7.71	4.59	1.15	.36	1.02
Timothy	7.52	4.93	1.26	.53	.90
Orchard grass	8.84	6.42	1.31	.41	1.88
Kentucky blue grass (*Poa pratensis*)	10.35	4.16	1.19	.40	1.57
Meadow fescue (*Festuca pratensis*)	8.89	8.08	.99	.40	2.10
Tall meadow oat grass (*Arrhenatherum avenaceum*)	15.35	4.92	1.16	.32	1.72
Meadow foxtail (*Alopecurus pratensis*)	15.35	5.24	1.54	.44	1.99
Perennial rye grass	9.13	6.79	1.23	.56	1.55
Italian rye grass	8.71	....	1.19	.56	1.27
Japanese buckwheat	5.72	....	1.63	.85	3.32
Red clover	11.33	6.93	2.07	.38	2.20
Mammoth red clover (*Trifolium medium*)	11.41	8.72	2.23	.55	1.22
White clover	....	....	2.75	.52	1.81
Crimson clover[2]	18.30	7.70	2.05	.40	1.31
Alsike clover	9.94	11.11	2.34	.67	2.23
Alfalfa	6.55	7.07	2.19	.51	1.68
Blue melilot (*Melilotus cœruleus*)	8.22	13.65	1.92	.54	2.80
Bokhara clover (*Melilotus alba*)	7.43	7.70	1.98	.56	1.83
Sainfoin (*Onobrychis sativa*)	12.17	7.55	2.63	.76	2.02
Sulla (*Hedysarum coronarium*)	9.39	....	2.46	.45	2.09
Lotus villosus	11.52	8.23	2.10	.59	1.81
Soja bean (whole plant)	6.30	6.47	2.32	.67	1.08
Soja bean (straw)	13.00	....	1.75	.40	1.32
Cowpea (whole plant)	10.95	8.40	1.95	.52	1.47
Serradella	7.39	10.60	2.70	.78	.65
Cotton (entire plant)	7.36	5.81	1.46	.44	1.32
Oxeye daisy (*Chrysanthemum leucanthemum*)	9.65	6.37	.28	.44	1.25
Dry carrot tops	9.76	12.52	3.13	.61	4.88
Barley straw	11.44	5.30	1.31	.30	2.09
Barley chaff	13.08	....	1.01	.27	.99
Wheat straw	12.56	3.81	.59	.12	.51
Wheat chaff	8.05	7.18	.79	.70	.42
Rye straw	7.61	3.25	.46	.28	.79
Oat straw	9.09	4.76	.62	.20	1.24
Buckwheat hulls	11.90	....	.49	.07	.52

[1]Dietrich and König: Zusamensetzung und Verdaulichkeit der Futtermittel.
[2]Dietrich and König.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS—Continued.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
ROOTS, BULBS, TUBERS, ETC.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Potatoes	79.24	.89	.32	.12	.46
Red beets	87.73	1.13	.24	.09	.44
Yellow fodder beets	90.60	.95	.19	.09	.46
Sugar beets	86.95	1.04	.22	.10	.48
Mangel-wurzels	87.29	1.22	.19	.09	.38
Turnips	89.49	1.01	.18	.10	.39
Ruta-bagas	89.13	1.06	.19	.12	.49
Carrots	89.79	9.22	.15	.09	.51
GRAINS AND OTHER SEEDS.					
Corn kernels	10.88	1.53	1.82	.70	.40
Sorghum seed	14.00	....	1.48	.81	.42
Barley [1]	14.30	2.48	1.51	.79	.48
Oats	18.17	2.98	2.06	.82	.62
Wheat (spring)	14.35	1.57	2.36	.70	.39
Wheat (winter)	14.75	....	2.36	.89	.61
Rye	14.90	....	1.76	.82	.54
Common millet	12.68	....	2.04	.85	.36
Japanese millet	13.68	....	1.73	.69	.38
Rice	12.60	.82	1.08	.18	.09
Buckwheat	14.10	....	1.44	.44	.21
Soja beans	18.33	4.99	5.30	1.87	1.99
Cotton seed	8.42	3.78	3.13	1.27	1.17
MILL PRODUCTS.					
Corn meal	12.95	1.41	1.58	.63	.40
Corn-and-cob meal	8.96	....	1.41	.57	.47
Ground oats	11.17	3.37	1.86	.77	.59
Ground barley	13.43	2.06	1.55	.66	.34
Rye flour	14.20	....	1.68	.85	.65
Wheat flour	9.83	1.22	2.21	.57	.54
Pea meal	8.85	2.68	3.08	.82	.99
BY-PRODUCTS AND WASTE MATERIALS.					
Corncobs	12.09	.82	.50	.06	.60
Hominy feed	8.93	2.21	1.63	.98	.49
Gluten meal	8.59	.73	5.03	.33	.05
Starch feed (glucose refuse)	8.10	....	2.62	.29	.15
Malt sprouts	18.38	12.48	3.55	1.43	1.63
Brewers' grains (dry)	9.14	3.92	3.62	1.03	.09
Brewers' grains (wet)	75.01	....	.89	.31	.05
Rye bran	12.50	4.60	2.32	2.28	1.40
Rye middlings [1]	12.54	3.52	1.84	1.26	.81
Wheat bran	11.74	6.25	2.67	2.89	1.61
Wheat middlings	9.18	2.30	2.63	.95	.63
Rice bran	10.20	12.94	.71	.29	.24
Rice polish	10.30	9.00	1.97	2.67	.71
Buckwheat middlings [1]	14.70	1.40	1.38	.68	.34
Cotton-seed meal	7.81	6.95	6.79	2.88	.87
Cotton-seed hulls	10.17	2.40	.69	.25	1.02
Linseed meal (old process)	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process)	7.77	5.37	5.78	1.83	1.39
Peanut-cake meal	10.40	3.97	7.56	1.31	1.50
Apple pomace	80.50	.27	.23	.02	.13
VEGETABLES.					
Artichokes	81.50	.99	.36	.17	.48
Asparagus stems	93.96	.67	.29	.08	.29
Beans, adzuki	15.86	3.53	3.29	.95	1.51
Beets, red	88.47	1.04	.24	[2] .09	[2] .44
Cabbages	90.52	1.40	.38	[2] .11	[2] .43
Carrots	88.59	1.02	.16	.09	.51
Cauliflower	90.82	.81	.13	.16	.36
Chorogi tubers	78.90	1.09	1.92	.19	.64
Cucumbers	95.99	.46	.16	.12	.24
Horse-radish root	76.68	1.87	.36	.07	1.16
Kohl-rabi	91.08	1.27	.48	.27	.43
Lettuce, whole plant	93.68	1.61	.23	[2] .07	[2] .37
Onions	87.55	.57	.14	.04	.10
Parsnips	80.34	1.03	.22	.19	.62
Peas:					
Garden	12.62	3.11	3.58	.84	1.01
Small (*Lathyrus sativus*), whole plant	5.80	5.94	2.50	.59	1.99

[1] Dietrich and König. [2] Wolff.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS—Continued.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
VEGETABLES—continued.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Pumpkins, whole fruit	92.27	.63	[1].11	[1].16	[1].09
Rhubarb:					
Roots	74.35	2.28	.55	.06	.53
Stems and leaves	91.67	1.72	.13	.02	.36
Ruta-bagas	88.61	1.15	.19	.12	.49
Spinach	92.42	1.94	.49	.16	.27
Sweet corn:					
Cobs	80.10	.59	.21	.05	.22
Husks	86.19	.56	.18	.07	.22
Kernels	82.14	.56	.46	.07	.24
Stalks	80.86	1.25	.28	.14	.41
Sweet potatoes:					
Tubers	72.96	.95	.23	.10	.50
Vines	83.06	2.45	.42	.07	.73
Tomatoes:					
Fruits	93.64	.47	.16	.05	.27
Roots	73.31	11.72	.24	.06	.29
Vines	83.61	3.00	.32	.07	.50
Turnips	90.46	.80	.18	.10	.39
FRUITS AND NUTS.					
Apple leaves:					
Collected in May	72.36	2.33	.74	.25	.25
Collected in September	60.71	3.46	.89	.19	.39
Apples, fruit	85.30	.39	.13	.01	.19
Apple trees (young):					
Branches	83.60	.65	----------	.04	.04
Roots	64.70	1.59	----------	.11	.09
Trunks	51.70	1.17	----------	.06	.06
Whole plant	60.83	----------	.35	.05	.17
Apricots, fresh	85.16	.49	.19	.06	.29
Blackberries	88.91	.58	.15	.09	.20
Blueberries	82.69	.16	.14	.05	.05
Cherries, fruit	86.10	.58	.18	[2].06	[2].20
Cherry trees (young):					
Branches	79.50	.78	----------	.05	.06
Roots	67.20	1.22	----------	.08	.07
Trunks	53.20	.81	----------	.04	.06
China berries	16.52	4.13	1.19	.43	2.33
Cranberries:					
Fruit	89.59	.18	----------	.03	.09
Vines	----------	2.45	----------	.27	.32
Currants	86.02	.53	----------	.11	.27
Grapes, fruit, fresh	83.00	.50	.16	.09	.27
Grapes, wood of vine	----------	2.97	----------	.42	.67
Lemons	83.83	.56	.15	.06	.27
Nectarines	79.00	.50	.12	----------	----------
Olives:					
Fruit	58.00	1.42	.18	.12	.86
Leaves	42.40	2.51	.91	.26	.76
Wood of larger branches	14.50	.94	.88	.11	.18
Wood of small branches	18.75	.96	.89	.12	.20
Oranges:					
California	85.21	.43	.19	.05	.21
Florida	87.71	----------	.12	.08	.48
Peaches:					
Fruit	87.85	.32	----------	.05	.24
Wood of branches	58.26	1.93	.90	.22	.50
Pears, fruit	83.92	.54	.09	.03	.08
Pear trees (young):					
Branches	84.00	.76	----------	.04	.08
Roots	66.70	1.40	----------	.07	.11
Trunks	49.30	1.71	----------	.07	.13
Plums	47.43	.54	.18	.02	.24
Prunes	77.38	.49	.16	.07	.31
Raspberries	81.82	.55	.15	.48	.35
Strawberries:					
Fruit	90.84	.60	.15	.11	.30
Vines	----------	3.34	----------	.48	.35
Chestnuts, native	40.00	1.62	1.18	.39	.63
Peanuts:					
Hulls	10.60	3.00	1.14	.17	.95
Kernels	6.30	3.20	4.51	1.24	1.27
Vines (cured)	7.83	15.70	1.76	.29	.98

[1] Wolff.

[2] Dietrich and König.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS—Continued.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
DAIRY PRODUCTS.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Whole milk	87.00	.75	.53	.19	.18
Skim milk	90.25	.80	.56	.20	.19
Cream	74.05	.50	.40	.15	.13
Buttermilk	90.50	.70	.48	.17	.16
Whey	92.97	.60	.15	.14	.18
Butter	79.10	.15	.12	.04	.04
Cheese	33.25	2.10	3.93	.60	.12
WOODS.					
Ash, wood	10.00	.32	......	.012	.149
Chestnut:					
Bark	10.00	3.51	......	.114	.278
Wood	10.00	.16	......	.011	.029
Dogwood:					
Bark	10.00	9.87	......	.140	.341
Wood	10.00	.68	......	.057	.190
Hickory:					
Bark	10.00	3.97	......	.061	.141
Wood	10.00	.48	......	.058	.138
Magnolia:					
Bark	10.00	2.98	......	.095	.192
Wood	10.00	.36	......	.032	.071
Maple, bark	10.00	9.49	......	.421	1.197
Oak:					
Leaves, mixed	......	4.70	......	......	......
Post, bark	10.00	12.10	......	.116	.249
Post, wood	10.00	.77	......	.070	.169
Red, bark	10.00	6.29	......	.103	.179
Red, wood	10.00	.57	......	.060	.140
White, bark	10.00	5.95	......	.074	.125
White, wood	10.00	.26	......	.025	.106
Pine:					
Burr	......	1.09	......	......	......
Georgia, bark	10.00	.37	......	.013	.024
Georgia, wood	10.00	.33	......	.012	.050
Old field, bark	10.00	1.94	......	.095	.077
Old field, wood	10.00	.18	......	.007	.008
Straw, mixed	......	1.65	......	......	......
Yellow, wood	10.00	.23	......	.010	.045
Black, wood	10.00	.21	......	.009	.030
Sycamore, wood	10.00	.99	......	.121	.230

FERTILIZING CONSTITUENTS CONTAINED IN A CROP OF COTTON YIELDING 300 POUNDS OF LINT PER ACRE.

[J. B. McBryde.]

Fertilizing constituents (calculated).	Pounds per acre.						
	In 300 pounds lint.	In 654 pounds seed.	In 404 pounds bolls.	In 575 pounds leaves.	In 658 pounds stems.	In 250 pounds roots.	In 2,841 pounds total crop.
Nitrogen	0.72	20.08	4.50	13.85	5.17	1.62	45.94
Phosphoric acid, P_2O_5	.18	6.66	1.14	2.57	1.22	.38	12.15
Potash, K_2O	2.22	7.63	12.20	6.57	7.74	2.75	39.11
Soda, Na_2O	.08	.12	.19	1.61	.65	.38	3.03
Lime, CaO	.46	1.22	3.75	31.57	5.59	1.36	43.95
Magnesia, MgO	.41	3.26	1.01	5.73	2.43	.80	13.64
Sulphuric acid, SO_3	.26	.84	1.75	3.38	.74	.28	7.25
Insoluble matter	.08	.15	1.14	6.43	.89	.55	9.24

ANALYSES OF FERTILIZERS.

Fertilizer.	Moisture.	Nitrogen.	Potash.	Phosphoric acid. Soluble.	Phosphoric acid. Reverted	Phosphoric acid. Total.	Lime.	Magnesia.	Sulphuric acid.	Chlorin.
COMMERCIAL FERTILIZERS.										
Ashes:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Limekiln	15.45		1.20			1.14	48.50	2.60		
Wood, leached	30.22		1.27			1.51	28.08	2.66	0.14	
Wood, unleached	12.50		5.25			1.70	34.00	3.40		
Bat guano	40.09	8.20	1.31	2.37	1.24	3.80				
Bone ash	7.00					35.89	44.89			
Bone black	4.60					28.28				
Dissolved				15.40	1.30	17.00				
Bone meal	7.50	4.05		.40	7.60	23.25				
Dissolved		2.60		13.53		17.60				
Free from fat		6.20				20.10				
From glue factory		1.70				29.90				
Castor pomace	9.50	5.50	1.10			1.75				
Cotton-hull ashes	7.80		22.75	1.25	6.50	8.85	9.60	10.75		
Cotton-seed meal:										
Decorticated	7.81	6.79	1.77			2.88				
Undecorticated		4.30	1.50			3.10				
Dried blood	12.50	10.52				1.91				
Dried fish	12.75	7.25		.55	2.60	8.25				
Gas lime	22.28						43.66	8.30	20.73	
Kainit	3.20		13.54				1.15	9.80	20.25	33.25
Meat scrap	12.00	10.44				2.07				
Mona Island guano	13.32	.76			7.55	21.88	37.49			
Muck	50.00	1.10	.15			.10				
Muriate of potash	2.00		51.48							48.80
Navassa phosphate	7.60					34.27	37.45			
Nitrate of potash	1.93	13.09	45.19							
Nitrate of soda	1.40	15.70								
Oyster-shell lime[1]	15.00		.05			.18	55.00	.35	.60	
Seaweed	81.95	.29	.40			.08				
Seaweed ashes	1.47		.92			.30	6.05	4.37	2.98	6.60
South Carolina rock:										
Dissolved				11.60		15.20				
Ground	1.50			.27	.07	28.03	41.87	3.03		
Sulphate of ammonia	1.00	20.50							60.00	
Sulphate of potash (high grade)	2.54		33.40						45.72	
Tankage	10.00	6.70		.30	5.10	11.80				
Thomas slag	1.45				3.06	23.49	48.66	3.42		
Tobacco stalks	6.18	3.71	5.02			.65	2.22	.59		
Tobacco stems	10.00	2.35	8.20			.70	4.20	.80	.65	.65
FARM MANURES.										
Cattle excrement (solid, fresh)		.29	.10			.17				
Cattle urine (fresh)		.58	.49							
Hen manure (fresh)	60.00	1.10	.56			.85				
Horse excrement (solid)		.44	.35			.17				
Horse urine (fresh)		1.55	1.50							
Human excrement (solid)	77.20	1.00	.25			1.09				
Human urine	95.90	.60	.20			.17				
Pigeon manure (dry)	10.00	3.20	1.00			1.90	2.10	.80	.60	.50
Poudrette (night soil)	50.00	.80	.30			1.40	.80	.60	.40	.08
Sheep excrement (solid, fresh)		.55	.15			.31				
Sheep urine (fresh)		1.95	2.26			.01				
Stable manure (mixed)	73.27	.50	.60			.30				
Swine excrement (solid, fresh)		.60	.13			.41				
Swine urine (fresh)		.43	.83			.07				
Barnyard manure (average)	68.87	.49	.43			.32				

[1] 18.5 carbonate.

BARNYARD MANURE.

Barnyard manure contains all the fertilizing elements required by plants in forms that insure plentiful crops and permanent fertility to the soil. It not only enriches the soil with the nitrogen, phosphoric acid, and potash, which it contains, but it also renders the stored-up materials of the soil more available, improves the mechanical condition of the soil, makes it warmer, and enables it to retain more moisture or to draw it up from below.

On the basis of the prices charged for commercial fertilizers, the fertilizing value of the manure produced by the farm animals of the United States last year was upward of $2,000,000,000. The average for each horse is estimated at $27, for each head of cattle $19, for each hog $12, and for each sheep $2.

Amount and value of manure produced by different farm animals.

[New York Cornell Experiment Station.]

Animal.	Per 1,000 pounds of live weight.			Value of manure per ton.
	Amount per day.	Value per day.[1]	Value per year.[1]	
	Pounds.	*Cents.*		
Sheep	34.1	7.2	\$26.09	\$3.30
Calves	67.8	6.2	24.45	2.18
Pigs	83.6	16.7	60.88	3.29
Cows	74.1	8.0	29.27	2.02
Horses	48.8	7.6	27.74	2.21

[1] Valuing nitrogen at 15 cents, phosphoric acid at 6 cents, and potash at $4\frac{1}{2}$ cents per pound.

Barnyard manure is a very variable substance, its composition and value depending principally upon (1) age and kind of animal, (2) quantity and quality of food, (3) proportion of litter, and (4) method of management and age of manure.

Mature animals, neither gaining nor losing weight, excrete practically all the fertilizing constituents consumed in the food. Growing animals and milch cows excrete from 50 to 75 per cent of the fertilizing constituents of the food; fattening or working animals from 90 to 95 per cent. As regards the fertilizing value of equal weights of manure in its normal condition, farm animals probably stand in the following order: Poultry, sheep, pigs, horses, cows.

The amounts of fertilizing constituents in the manure stand in direct relation to those in the food. As regards the value of manure produced, the concentrated feeding stuffs, such as meat scrap, cotton-seed meal, linseed meal, and wheat bran, stand first, the leguminous plants (clover, peas, etc.) second, the grasses third, cereals (oats, corn, etc.) fourth, and root crops, such as turnips, beets, and mangel-wurzels, last.

Barnyard manure is a material which rapidly undergoes change. When it is practical to haul the manure from the stalls and pen and spread it on the field at frequent intervals the losses of valuable constituents need not be very great, but when (as in winter) the manure must be stored for some time the difficulties of preservation become greatly increased.

The deterioration of manure results from two chief causes, (1) fermentation and (2) weathering or leaching. The loss from destructive fermentation may be almost entirely prevented by the use of proper absorbents and preservatives, such as gypsum, superphosphate, and kainit, and by keeping the manure moist and compact.

Amounts of different preservatives to be used per head daily.

Preservative.	Per horse, 1,000 pounds' weight.		Per cow, 880 pounds' weight.		Per pig, 220 pounds' weight.	Per sheep, 110 pounds' weight.
	Lbs.	*Ozs.*	*Lbs.*	*Ozs.*	*Ounces.*	*Ounces.*
Superphosphate	1	0	1	2	3	$2\frac{1}{4}$
Gypsum	1	9	1	12	$4\frac{7}{8}$	$3\frac{3}{8}$
Kainit	1	2	1	5	4	$3\frac{1}{8}$

If both superphosphate and gypsum are used, the above proportions of these materials should be reduced from one-third to one-half. Kainit should be applied to the fresh manure and covered with litter so that it does not come in contact with the feet of the animals.

Loss from leaching may be prevented by storage under cover or in pits. Extremes of moisture and temperature are to be avoided, and uniform and moderate fermentation is the object to be sought. To this end it is advisable to mix the manure from the different animals thoroughly in the heap.

Barnyard manure is justly held in high esteem as a general fertilizer, but it has a forcing effect when fresh, and is therefore better suited to grasses and forage plants than to plants grown for seed, such as cereals. Direct applications, especially to root crops, such as sugar beets, potatoes, or tobacco, often prove injurious. This result can, as a rule, be avoided by applying the manure some months before the planting of the crop or by using only well-rotted manure.

Barnyard manure is not applied to fruit trees with the same good results that attend its use in the case of field crops, garden truck, etc. It does not stimulate fruiting to the same extent as do the mineral fertilizers. Its tendency is to produce a large growth, but a poor quality, of fruit. Oranges, in particular, become coarse, thick skinned, and sour under its influence.

As a rule the best results are likely to be obtained by using commercial fertilizing materials in connection with barnyard manure, either in compost or separately.

CUTS OF MEATS.

The methods of cutting sides of beef, mutton, and veal and pork into parts and the terms used for the "cuts," as these parts are commonly called, vary in different localities. The terms used in the table which follows and generally in publications of this Department will be made more clear by the following diagrams:[1]

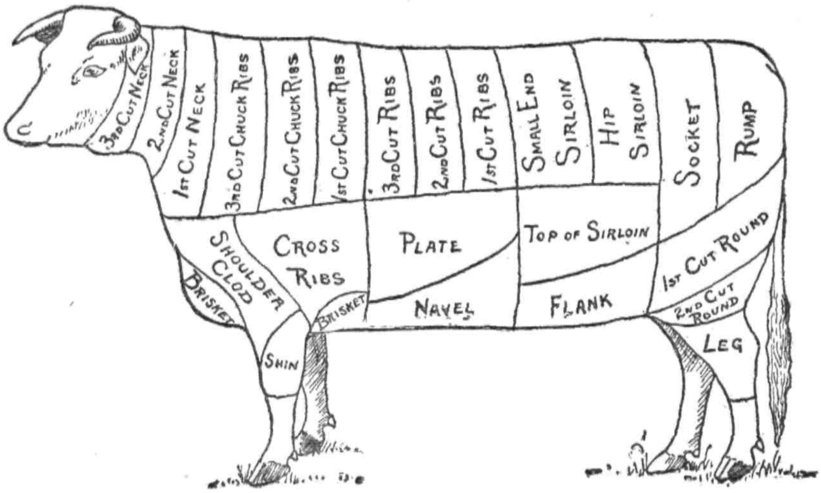


FIG. 130.—Diagram of cuts of beef.

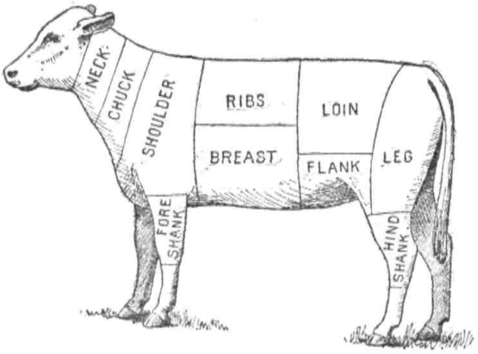


FIG. 131.—Diagram of cuts of veal.

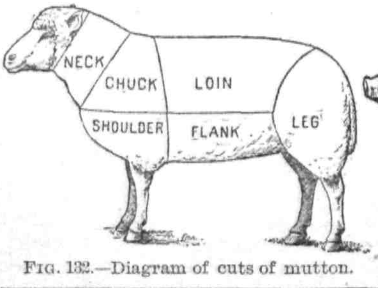


FIG. 132.—Diagram of cuts of mutton.

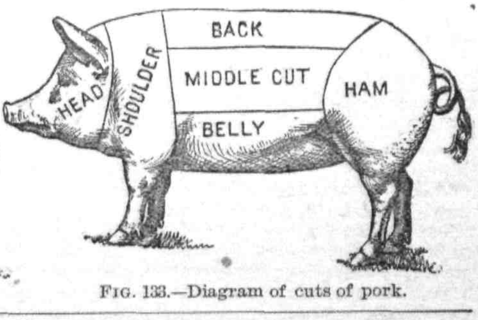


FIG. 133.—Diagram of cuts of pork.

[1] From Farmers' Bulletin No. 34.

HUMAN FOODS.

Within recent years analyses of a large number of samples of food materials have been made in this country. In the table given below the average results of these analyses are shown. Brief explanatory notes regarding the nutritive ingredients of food and their uses in the body are also given, which may serve to make the table more intelligible.

NUTRITIVE INGREDIENTS OF FOOD AND THEIR USES IN THE BODY.

Food as purchased contains—
- Edible portion: Flesh of meat, yolk and white of eggs, wheat flour, etc.
  - Water.
  - Nutrients.
    - Protein.
    - Fats.
    - Carbohydrates.
    - Mineral matters.
- Refuse: Bones, entrails, shells, bran, etc.

USES OF NUTRIENTS.

Nutrient	Use	
Protein (White (albumen) of eggs, curd (casein) of milk, lean meat, gluten of wheat, etc.)	Forms tissue (muscle, tendon, fat).	All serve as *fuel* and yield *energy* in form of heat and muscular strength.
Fats (Fat of meat, butter, olive oil, oils of corn and wheat, etc.)	Form fatty tissue.	
Carbohydrates (Sugar, starch, etc.)	Transformed into fat.	
Mineral matters (ash) (Phosphates of lime, potash, soda, etc.)	Aid in forming bone, assist in digestion, etc.	

The fuel value of food.—Heat and muscular power are forms of force or energy. The energy is developed as the food is consumed in the body. The unit commonly used in this measurement is the calorie, the amount of heat which would raise the temperature of a pound of water 4° F.

The following general estimate has been made for the average amount of potential energy in 1 pound of each of the classes of nutrients:

	Calories.
In 1 pound of protein	1,860
In 1 pound of fats	4,220
In 1 pound of carbohydrates	1,860

In other words, when we compare the nutrients in respect to their fuel values, their capacities for yielding heat and mechanical power, a pound of protein of lean meat or albumen of egg is just about equivalent to a pound of sugar or starch, and a little over 2 pounds of either would be required to equal a pound of the fat of meat or butter or the body fat.

Average composition of American food products.[1]

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD.								
Beef, fresh.								
Brisket:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Medium fat	1	14.3	40.6	12.5	31.9	....	0.7	1,580
Chuck, including shoulder:								
Lean	9	23.7	54.3	15.2	6.0	....	.8	535
Medium fat	7	17.0	56.3	15.7	10.2	....	.8	720
Fat	3	14.7	53.3	15.4	15.9	....	.7	955
All analyses	23	19.9	54.1	15.3	9.9	....	.8	705
Chuck ribs:								
Lean	1	9.8	59.7	16.3	13.3	....	.9	865
Medium fat	4	13.8	49.3	15.0	21.1	....	.8	1,170
Fat	1	15.0	43.6	13.6	27.2	....	.6	1,400
All analyses	6	13.3	50.1	15.0	20.8	....	.8	1,155
Flank:								
Lean	2	2.1	64.9	19.3	12.7	....	1.0	895
Medium fat	4	3.8	57.5	17.2	20.7	....	.8	1,195
Fat	2	5.0	51.5	15.6	27.2	....	.7	1,435
All analyses	11	3.8	54.4	16.7	24.3	....	.8	1,335

[1] Condensed from detailed tables in Bulletin No. 23 of the Office of Experiment Stations of this Department.

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.								
Beef, fresh—Continued.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Loin:								
Lean	11	13.1	58.2	16.7	11.1		.9	780
Medium fat	28	13.0	52.6	15.9	17.6		.9	1,040
Fat	6	10.2	49.2	15.8	24.0		.8	1,305
All analyses	48	12.6	53.3	15.9	17.3		.9	1,025
Loin, boneless strip:								
Lean	1		66.3	20.5	12.2		1.0	895
Medium fat	2		58.1	21.0	19.8		1.1	1,230
Fat	1		53.6	16.8	28.8		.8	1,530
All analyses	6		60.7	18.9	19.5		.9	1,175
Loin, sirloin butt:								
Lean	1		68.5	19.8	10.7		1.0	820
Medium fat	2		62.1	19.7	17.2		1.0	1,095
Fat	1		58.6	17.1	23.5		.8	1,310
All analyses	6		62.5	18.9	17.7		.9	1,100
Loin, tenderloin:								
Lean	2		63.4	17.2	18.5		.9	1,100
Medium fat	4		57.1	14.8	27.3		.8	1,430
All analyses	6		59.2	15.6	24.4		.8	1,320
Loin, top of sirloin:								
Medium fat	1	3.2	40.9	12.9	42.3		.7	2,025
Loin, trimmings:								
Lean	2	57.6	28.1	8.0	5.9		.4	400
Medium fat	1	38.0	33.7	9.9	17.8		.6	935
Fat	3	46.6	25.7	7.8	19.5		.4	965
All analyses	6	48.8	27.9	8.2	14.7		.4	775
Neck:								
Lean	1	29.0	50.4	14.2	5.7		.7	505
Medium fat	10	27.6	45.9	13.9	11.9		.7	760
All analyses	12	28.4	46.3	13.9	10.7		.7	710
Plate:								
Lean	3	17.3	54.4	12.2	15.5		.6	880
Medium fat	6	15.2	45.4	13.2	25.5		.7	1,320
Fat	2	16.5	37.3	11.6	34.0		.6	1,650
All analyses	14	16.7	46.0	12.7	23.9		.7	1,245
Ribs:								
Lean	6	22.6	52.6	14.8	9.3		.7	670
Medium fat	14	20.8	43.8	13.4	21.3		.7	1,150
Fat	7	16.1	39.5	12.6	31.2		.6	1,550
All analyses	28	20.2	44.9	13.6	20.6		.7	1,120
Rib rolls:								
Lean	3		69.0	19.5	10.5		1.0	805
Medium fat	4		63.9	18.5	16.7		.9	1,050
Fat	2		51.5	16.4	31.3		.8	1,630
All analyses	11		64.8	18.7	15.6		.9	1,005
Rib trimmings:								
Medium fat	7	34.8	37.4	10.9	16.3		.6	890
Fat	2	34.0	31.5	9.3	24.8		.4	1,220
All analyses	11	34.1	35.7	10.5	19.2		.5	1,005
Ribs, cross:								
Medium fat	1	12.2	38.6	12.0	36.5		.7	1,765
All analyses	2	12.5	48.0	14.1	24.7		.7	1,305
Round:								
Lean	23	8.8	64.2	18.9	7.1		1.0	650
Medium fat	15	7.7	60.7	18.1	12.6		.9	870
Fat	1		57.8	18.9	22.3		1.0	1,295
All analyses	44	8.5	63.0	18.7	8.8		1.0	720
Rump:								
Lean	2	20.2	51.7	15.7	11.6		.8	780
Medium fat	8	21.4	44.5	13.2	20.2		.7	1,095
Fat	4	23.2	36.9	11.4	27.9		.6	1,390
All analyses	19	18.5	47.3	14.4	19.0		.8	1,070
Shank, fore:								
Lean	5	36.5	45.4	13.6	3.9		.6	420
Medium fat	5	36.9	42.9	12.3	7.3		.6	535
All analyses	13	36.5	44.1	13.1	5.7		.6	485
Shank, hind:								
Lean	5	56.6	31.6	9.1	2.2		.5	260
Medium fat	6	53.9	31.3	9.1	5.3		.4	395
Fat	1	51.6	29.7	9.2	9.1		.4	555
All analyses	12	54.8	31.3	9.2	4.3		.4	355
Shoulder clod:[1]								
Lean	2	8.1	66.9	18.8	5.2		1.0	570
Medium fat	12	16.4	56.8	11.1	9.8		.9	715
Fat	3	11.9	52.8	16.7	17.7		.9	1,060
All analyses	19	14.6	57.9	16.8	9.7		1.0	725
Socket	1	35.8	36.7	10.7	16.2		.6	880

[1] Including, in most cases, some bone.

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.								
Beef, fresh—Continued.								
Fore quarter:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Lean	3	21.8	53.8	14.1	9.7	....	.6	670
Medium fat	6	19.3	48.6	14.1	17.3	....	.7	990
Fat	1	21.7	41.9	12.4	23.4	....	.6	1,220
All analyses	12	19.8	49.3	14.1	16.1	....	.7	940
Hind quarter:								
Lean	3	16.5	55.9	16.0	10.8	....	.8	755
Medium fat	7	16.4	50.4	14.9	17.5	....	.8	1,015
Fat	1	14.1	50.0	14.8	20.4	....	.7	1,135
All analyses	12	16.3	52.0	15.3	15.6	....	.8	945
Side	12	18.3	50.4	14.6	16.0	....	.7	945
Liver	3	69.8	21.6	5.4	1.8	....	1.4	665
Sweetbreads	1	....	70.9	15.4	12.1	....	1.6	795
Tongue	1	15.1	53.9	14.8	15.3	....	.9	920
Beef, canned.								
Boiled	1	....	51.8	24.4	22.5	....	1.3	1,405
Corned, cooked:								
Medium fat	6	....	53.1	28.5	14.0	....	4.4	1,120
Fat	4	....	51.6	24.7	20.7	....	3.0	1,330
All analyses	12	....	51.2	25.9	18.9	....	4.0	1,280
Dried	2	....	44.8	38.6	5.4	....	11.2	950
Roast	4	....	58.9	25.0	14.8	....	1.3	1,090
Steak, rump	1	....	56.3	23.5	18.7	....	1.5	1,225
Tongue, whole	5	....	51.3	21.5	23.2	....	4.0	1,380
Tripe	2	....	74.6	16.4	8.5	....	.5	665
Beef, corned and pickled.								
Corned beef:								
All analyses	9	9.4	49.6	14.2	22.8	....	4.0	1,225
Mess	2	10.5	33.0	10.7	39.9	....	5.9	1,885
Tongue, pickled	2	6.0	58.9	11.6	19.2	....	4.3	1,025
Tripe, pickled	2	....	87.4	10.9	1.2	.3	.2	260
Beef, dried, etc.								
Dried, salted, and smoked	5	....	50.8	31.8	6.8	.6	10.0	890
Veal, fresh.								
Breast:								
Lean	2	23.4	54.0	15.7	6.2	....	.7	555
Medium fat	5	20.6	52.7	14.9	11.0	....	.8	740
All analyses	7	21.4	53.1	15.1	9.6	....	.8	685
Chuck:								
Medium fat	6	18.9	59.5	15.6	5.2	....	.8	510
Flank:								
Medium fat	5	....	68.9	19.7	10.4	....	1.0	805
Fat	1	....	57.0	18.0	24.1	....	.9	1,255
All analyses	6	....	66.9	19.4	12.7	....	1.0	895
Leg:								
Lean	8	6.6	69.3	19.6	3.4	....	1.1	510
Medium fat	6	15.6	59.4	16.9	7.2	....	.9	620
All analyses	14	10.5	65.0	18.5	5.0	....	1.0	555
Leg cutlets	2	4.0	65.6	20.0	9.5	....	.9	775
Loin:								
Lean	4	20.3	58.1	16.1	4.6	....	.9	495
Medium fat	5	17.3	57.2	16.0	8.6	....	.9	660
Fat	2	18.3	50.4	15.1	15.4	....	.8	930
All analyses	11	18.6	56.2	15.9	8.4	....	.9	650
Loin, with kidney	1	9.1	66.7	12.8	10.7	....	.7	690
Neck:								
Medium fat	6	31.5	49.9	13.3	4.6	....	.7	440
Rib:								
Medium fat	8	26.9	53.0	14.7	4.6	....	.8	470
Fat	1	22.4	52.6	15.5	8.6	....	.9	650
All analyses	9	26.4	53.0	14.8	5.0	....	.8	485
Rump	1	39.2	43.7	14.0	11.3	....	.8	735
Shank, fore	6	40.1	44.1	11.8	3.1	....	.6	350
Shank, hind:								
Medium fat	6	62.7	27.8	7.4	1.7	....	.4	210
Fat	1	51.4	33.1	9.7	5.2	....	.6	400
All analyses	7	61.1	28.6	7.7	2.2	....	.4	235
Shoulder and flank	1	24.3	49.7	14.9	10.2	....	.9	710
Shoulder	2	16.6	57.2	16.6	8.7	....	.9	675
Forequarter	6	24.5	54.2	14.6	6.0	....	.7	525

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.								
Veal, fresh—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Hind quarter	6	20.7	56.2	15.7	6.6	....	.8	570
Side	6	22.6	55.2	15.1	6.3	....	.8	545
Liver	2	....	73.1	20.4	5.3	....	1.2	605
Lamb, fresh.								
Breast	1	19.1	45.5	15.5	19.1	....	.8	1,095
Leg, hind:								
Medium fat	2	17.4	52.9	15.2	13.6	....	.9	855
Fat	1	13.4	47.3	14.8	23.7	....	.8	1,275
All analyses	4	13.8	50.3	15.3	19.7	....	.9	1,115
Loin, without kidney and tallow:								
Medium fat	4	14.8	45.3	15.0	24.1	....	.8	1,295
Neck	1	17.7	46.7	14.4	20.4	....	.8	1,130
Shoulder	1	20.3	41.3	14.0	23.6	....	.8	1,255
Fore quarter	1	18.8	44.7	14.7	21.0	....	.8	1,160
Hind quarter	1	15.7	51.3	16.0	16.1	....	.9	975
Side, without kidney and tallow	3	19.3	47.0	14.2	18.7	....	.8	1,055
Lamb, canned.								
Tongue	1	2.6	65.7	13.9	17.3	....	.5	990
Mutton, fresh.								
Chuck:								
Medium fat	6	21.3	39.9	11.5	26.7	....	.6	1,340
Fat	2	16.5	33.8	11.5	37.5	....	.7	1,795
All analyses	9	19.4	37.0	11.1	31.8	....	.7	1,550
Flank:								
Medium fat	7	....	45.8	14.8	38.7	....	.7	1,910
All analyses	9	....	42.0	13.9	43.4	....	.7	2,090
Leg, hind:								
Lean	3	16.8	56.1	15.9	10.3	....	.9	730
Medium fat	10	18.0	51.4	14.9	14.9	....	.8	905
Fat	1	12.4	48.2	14.8	23.8	....	.8	1,280
All analyses	14	17.4	52.2	15.1	14.5	....	.8	895
Loin, without kidney and tallow:								
Medium fat	11	15.3	42.2	13.2	28.6	....	.7	1,450
Fat	3	11.7	38.3	12.5	36.8	....	.7	1,785
All analyses	15	14.2	40.5	12.8	31.9	....	.6	1,585
Neck:								
Medium fat	9	28.4	41.6	11.7	17.6	....	.7	960
All analyses	10	27.2	41.0	11.7	19.4	....	.7	1,035
Shoulder:								
Lean	1	25.3	50.2	14.2	9.6	....	.7	670
Medium fat	6	21.7	48.5	13.5	15.6	....	.7	910
Fat	1	19.5	42.7	12.8	24.4	....	.6	1,270
All analyses	9	21.5	47.0	13.4	17.4	....	.7	985
Fore quarter	9	21.1	40.6	11.9	25.7	....	.7	1,305
Hind quarter, without tallow and kidney	9	16.7	45.6	13.5	23.5	....	.7	1,245
Side, including tallow	25	18.1	45.4	12.7	23.1	....	.7	1,210
Side, not including tallow	9	19.0	43.0	12.7	24.6	....	.7	1,275
Mutton, canned.								
Corned	1	....	45.8	27.2	22.8	....	4.2	1,470
Tongue, canned	1	....	47.6	23.6	24.0	....	4.8	1,450
Pork, fresh.								
Chuck ribs and shoulder:								
Medium fat	2	18.1	41.8	13.8	25.5	....	.8	1,335
Flank cut	3	71.2	17.0	5.1	6.4	....	.3	365
Ham	4	42.4	35.7	10.7	10.6	....	.6	645
Head	3	68.4	13.7	3.8	13.9	....	.2	655
Head cheese	1	12.1	42.3	18.6	24.0	....	3.0	1,360
Loin:								
Lean	1	23.5	46.1	15.1	14.5	....	.8	895
Medium fat	11	15.8	43.8	14.1	25.6	....	.7	1,340
Fat	3	14.6	35.7	10.4	38.7	....	.6	1,825
All analyses	15	16.0	42.3	13.5	27.5	....	.7	1,410
Middle cuts	3	71.2	13.8	4.2	10.6	....	.2	525
Shoulder	5	32.5	35.9	10.4	20.7	....	.5	1,065
Shouldercut	3	59.6	19.1	5.3	15.7	....	.3	760
Tenderloin	3	....	65.1	19.5	14.4	....	1.0	970
Back fat	3	....	7.7	2.3	89.9	....	.1	3,835
Belly fat	3	....	13.8	4.1	81.9	....	.2	3,530
Ham fat	3	....	9.1	2.7	88.0	....	.2	3,765

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.								
Pork, salted, cured, and pickled.								
Ham, smoked:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Lean	3	11.5	47.2	17.9	18.5	....	4.9	1,115
Medium fat	13	14.4	34.9	13.3	33.4	....	4.0	1,655
Fat	2	3.4	25.2	14.2	53.8	....	3.4	2,535
All analyses	8	12.7	35.9	14.1	33.2	....	4.1	1,665
Ham, boneless, raw, without case	4	....	50.1	15.4	28.5	....	6.0	1,490
Shoulder, smoked:								
Medium fat	3	15.2	36.8	12.9	26.6	....	5.5	1,360
Fat	2	20.0	21.4	11.8	42.6	....	4.2	2,015
All analyses	5	18.9	30.7	12.4	33.0	....	5.0	1,625
Dry salted backs	2	8.1	15.9	6.5	66.8	....	2.7	2,940
Dry salted belly	2	8.2	16.2	6.2	66.2	....	3.2	2,910
Salt pork	6	....	7.3	1.8	87.2	....	3.7	3,715
Salt pork, lean ends	4	11.2	17.6	6.5	59.6	....	5.1	2,635
Feet	2	35.5	44.6	10.0	9.3	....	.6	580
Bacon, smoked:								
Lean	1	9.6	29.6	14.9	40.8	....	5.1	2,000
Medium fat	12	8.0	16.8	9.2	61.8	....	4.2	2,780
All analyses	13	8.1	17.8	9.6	60.2	....	4.3	2,720
Pork side[1]	3	11.2	26.1	7.5	54.8	....	.4	2,455
Sausage.								
Bologna	4	3.3	55.2	18.0	19.7	....	3.8	1,165
Farmer	1	3.9	22.2	26.2	40.4	....	7.3	2,195
Frankfurt	6	....	55.5	21.7	18.8	.4	3.6	1,205
Pork	9	....	38.7	12.8	45.4	.8	2.3	2,170
Summer	3	7.0	20.9	23.0	42.1	....	7.0	2,200
Soups.								
Bouillon	2	....	96.5	2.0	.1	.2	1.2	45
Chicken	2	....	93.8	3.6	.1	1.5	1.0	100
Consommé	1	....	96.0	2.5	....	.4	1.1	55
Meat stew	3	....	85.7	4.5	3.5	5.1	1.2	325
Mock-turtle	2	....	89.8	5.2	.9	2.8	1.3	185
Ox-tail	1	1.8	87.8	3.8	.5	4.2	1.9	170
Pea	2	....	85.1	4.2	.5	9.0	1.2	265
Tomato	2	....	90.0	1.8	1.1	5.6	1.5	185
Turtle, green	1	....	86.6	6.1	1.9	3.9	1.5	270
Vegetable	1	....	95.7	2.9	....	.5	.9	65
Poultry and game, fresh.								
Chicken	2	34.8	48.5	14.8	1.1	....	.8	325
Goose	2	22.2	33.1	10.3	33.8	....	.6	1,620
Turkey	3	22.7	42.4	15.7	18.4	....	.8	1,070
Game, canned.								
Plover	1	....	57.7	22.4	10.2	7.6	2.1	990
Quail	1	....	66.9	21.8	8.0	1.7	1.6	775
Fish, fresh.								
Bass, black, whole	2	54.8	34.6	9.3	.8	....	.5	205
Bass, sea, whole	1	56.1	34.8	8.3	.2	....	.6	160
Bluefish, entrails removed	1	48.6	40.3	9.8	.6	....	.7	205
Cod, whole	2	52.5	38.7	8.0	.2	....	.6	155
Cod, dressed	3	29.9	58.5	10.6	.2	....	.8	205
Flounder, whole	2	61.5	32.1	5.6	.3	....	.5	115
Haddock, entrails removed	4	51.0	40.0	8.2	.2	....	.6	160
Halibut, steaks or sections	3	17.7	61.9	15.1	4.4	....	.9	465
Herring, whole	2	42.6	41.7	10.9	3.9	....	.9	370
Mackerel, whole	5	44.6	40.4	10.0	4.3	....	.7	370
Mackerel, entrails removed	1	40.7	43.7	11.4	3.5	....	.7	360
Perch, white, whole	2	62.5	28.4	7.2	1.5	....	.4	195
Perch, yellow, whole	1	62.7	30.0	6.7	.2	....	.4	135
Perch, yellow, dressed	1	35.1	50.7	12.6	.7	....	.9	265
Pickerel (pike), whole	2	47.1	42.2	9.8	.2	....	.7	190
Pickerel (pike), entrails removed	1	42.7	45.7	10.7	.3	....	.6	210
Pike, gray, whole	1	63.2	29.7	6.4	.3	....	.4	130
Red snapper, whole	2	46.1	42.0	10.6	.6	....	.7	220
Red snapper, entrails and gills removed	1	45.3	43.7	10.0	.3	....	.7	200
Salmon, whole	5	39.2	39.4	12.4	8.1	....	.9	570

[1] Lard and other fats included.

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.								
Fish, fresh—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Salmon, entrails removed	2	29.5	48.1	13.5	8.1	....	.8	590
Shad, whole	7	50.1	35.2	9.2	4.8	....	.7	375
Shad roe	1	....	71.2	20.9	3.8	2.6	1.5	600
Spanish mackerel, whole	1	34.6	44.5	13.7	6.2	....	1.0	515
Sturgeon, anterior sections	1	14.4	67.4	15.4	1.6	....	1.2	355
Trout, brook	3	48.1	40.4	9.8	1.1	....	.6	230
Fish, preserved and canned.								
Cod, salt	2	24.9	40.3	16.0	.4	....	18.4	315
Haddock, smoked	1	32.2	49.2	16.1	.1	....	2.4	305
Halibut, smoked	2	7.0	46.0	19.1	14.0	....	13.9	945
Herring, smoked, entrails removed	1	44.4	19.2	20.2	8.8	....	7.4	745
Mackerel, salt, dressed	2	19.7	34.8	13.9	21.2	....	10.4	1,150
Salmon, canned	3	14.2	56.8	19.5	7.8	....	2.0	680
Sardines	1	[1] 5.0	53.6	24.0	12.1	....	5.3	955
Shellfish, etc., fresh.								
Clams, in shell	4	41.9	49.9	5.0	.6	1.1	1.5	140
Crabs, hard, whole	1	52.4	36.7	7.9	.9	.6	1.5	195
Lobsters, whole	4	61.7	30.7	5.9	.7	.2	.8	145
Oysters in the shell	34	81.4	16.1	1.2	.2	.7	.4	45
Oyster, "solids"	6	....	88.3	6.1	1.4	3.3	.9	235
Terrapin	1	75.4	18.3	5.2	.9	....	.2	135
Turtle, green, whole	1	76.0	19.2	4.4	.1	....	.3	85
Shellfish, canned.								
Lobsters	5	....	77.8	18.1	1.1	.5	2.5	395
Shrimps	1	....	70.8	25.4	1.0	.2	2.6	520
Eggs.								
Hens' eggs	....	[2] 10.5	66.0	13.1	9.5	....	.9	645
Dairy products, etc.								
Butter	....	....	....	....	[3] 82.4	....	....	3,475
Whole milk	....	....	87.0	3.3	4.0	5.0	.7	325
Skim milk	....	....	90.5	3.4	.3	5.1	.7	170
Buttermilk	....	....	91.1	3.0	.5	4.8	.7	165
Cream	....	....	74.0	2.5	18.5	4.5	.5	910
Cheese, Cheddar	1	....	35.6	28.2	32.0	....	4.2	1,875
Cheese, Neufchatel	2	....	50.0	18.7	27.4	1.5	2.4	1,539
Cheese, Roquefort	1	....	39.3	22.6	29.5	1.8	6.8	1,700
Cheese, Swiss	2	....	31.4	27.6	34.9	1.3	4.8	2,010
Cheese, whole milk[4]	19	....	33.7	26.0	34.2	2.3	3.8	1,965
Cheese, partly skimmed[4]	3	....	38.2	25.4	29.5	3.6	3.3	1,785
Cheese, skim milk[4]	9	....	45.7	31.5	16.4	2.2	4.2	1,320
Miscellaneous.								
Gelatine	6	....	13.6	84.2	.1	....	2.1	1,570
Animal and other fats, except butter:								
Tallow, refined	....	....	....	....	100.0	....	....	4,220
Lard, refined	....	....	....	....	100.0	....	....	4,220
Cottolene	....	....	....	....	100.0	....	....	4,220
Oleomargarine	35	....	9.3	1.3	82.7	....	6.7	3,515
VEGETABLE FOOD.								
Flours, meals, etc.								
Entire wheat flour	5	....	12.1	14.2	1.9	70.6	1.2	1,660
Graham flour	6	....	11.8	13.7	2.2	70.3	2.0	1,655
Roller-process flour	100	....	12.5	11.3	1.1	74.6	.5	1,645
Spring-wheat flour	19	....	11.6	11.8	1.1	75.0	.5	1,660
Winter-wheat flour	13	....	12.5	10.4	1.0	75.6	.5	1,640
Macaroni and vermicelli	25	....	10.8	11.7	1.6	72.9	3.0	1,640
Barley meal	3	....	11.9	10.5	2.2	72.8	2.6	1,640
Barley, pearled	2	....	10.8	9.3	1.0	77.6	1.3	1,660
Buckwheat flour	10	....	14.3	6.1	1.0	77.2	1.4	1,590
Corn meal, bolted	9	....	12.9	8.9	2.2	75.1	.9	1,655

[1] Refuse, oil.
[2] Average per cent shell in several determinations.
[3] Average per cent butter fat found in the ninety-day Columbian butter test.
[4] American.

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
VEGETABLE FOOD—continued.								
Flours, meals, etc.—Continued.								
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Corn meal, unbolted	5	[1] 10.5	10.2	7.3	4.1	66.7	1.2	1,550
Corn hominy	5		11.9	8.2	.6	78.9	.4	1,645
Oatmeal	13		7.2	15.6	7.3	68.0	1.9	1,860
Oats, rolled	11		7.2	16.9	7.2	66.8	1.9	1,860
Pop corn, popped	2		4.3	10.7	5.0	78.7	1.3	1,875
Rice	13		12.4	7.8	.4	79.0	.4	1,630
Rye meal or flour	7		12.7	7.1	.9	78.5	.8	1,630
Bread, crackers, and pastry.								
Bread, white	108		35.4	9.5	1.2	52.8	1.1	1,205
Bread, brown	1		40.0	5.0	2.4	50.7	1.9	1,135
Bread, corn	2		38.0	8.5	2.7	47.3	3.5	1,150
Bread, graham	2		32.3	8.5	1.8	55.9	1.5	1,275
Bread, rye	4		31.8	10.1	.7	55.9	1.5	1,255
Cake	8		20.4	7.0	8.1	63.4	1.1	1,650
Crackers, Boston	1		8.2	10.7	9.9	68.8	2.4	1,895
Crackers, graham	1		5.0	9.8	13.6	69.7	1.9	2,050
Crackers, oyster	2		4.3	11.0	8.8	74.2	1.7	1,955
Crackers, soda	1		8.0	10.3	9.4	70.5	1.8	1,900
Doughnuts	5		17.9	6.6	21.9	52.6	1.0	2,025
Pie	10		44.8	4.6	9.5	39.6	1.5	1,220
Sugars.								
Honey, strained	30					75.1		1,395
Molasses	12		25.7	2.7		68.0	3.6	1,315
Sugar, granulated						100.0		1,860
Sugar, maple	17					82.8		1,540
Sirup, maple	50					70.1		1,395
Starches.								
Tapioca	2		11.6	.4	.3	87.5	.2	1,650
Starch						98.0		1,825
Vegetables.								
Asparagus	3		94.0	1.8	.2	3.3	.7	105
Beans, dried	9		13.2	22.3	1.8	59.1	3.6	1,590
Beets	17	20.0	70.0	1.3	.1	7.7	.9	170
Cabbage	7	15.0	76.8	1.8	.3	4.9	1.2	140
Carrots	17	20.0	70.5	.9	.3	7.4	.9	170
Cauliflower, head	1		90.8	1.6	.8	6.0	.8	175
Celery	1		94.4	1.4	.1	3.0	1.1	85
Citron melons	1		25.6	.4	.6	72.5	.9	1,380
Cowpeas, dried	11		13.0	21.3	1.4	60.9	3.4	1,590
Cucumbers	2	15.0	81.6	.7	.2	2.1	.4	60
Eggplant	1		92.9	1.2	.3	5.1	.5	130
Lettuce	6	18.0	77.1	1.1	.3	2.7	.8	85
Lima beans, dried	3		11.1	15.9	1.8	67.1	4.1	1,620
Lima beans, green	1		68.5	7.1	.7	22.0	1.7	570
Muskmelons	1	50.0	44.8	.3		4.6	.3	90
Okra	1		87.4	2.0	.4	9.5	.7	230
Onions	8	10.0	78.6	1.5	.4	8.9	.6	210
Parsnips	2	20.0	63.9	1.3	.5	12.9	1.4	285
Peas, dried	5		10.8	24.1	1.1	61.5	2.5	1,640
Peas, green	1	[2] 50.0	39.0	2.2	.3	8.0	.5	200
Pickles (cucumber)	1		89.0	.5	.5	5.4	4.6	130
Potatoes, raw	57	15.0	67.1	1.8	.1	15.3	.7	325
Pumpkins	3	50.0	46.6	.5		2.6	.3	60
Radishes	3	30.0	63.6	1.0	.1	4.6	.7	110
Rhubarb	2	40.0	56.6	.4	.4	2.2	.4	65
Sauerkraut	1		86.3	1.5	.8	4.4	7.0	145
Spinach	1		92.4	2.1	.5	3.1	1.9	120
Squash	7	50.0	43.3	.8	.3	5.2	.4	125
String beans	2		87.3	2.2	.4	9.4	.7	235
Sweet corn, edible portion	1		81.3	2.8	1.1	14.1	.7	360
Sweet potatoes	88	15.0	58.9	1.5	.6	23.1	.9	480
Tomatoes, fresh	20		94.4	.8	.4	3.9	.5	105
Turnips	14	30.0	62.2	1.0	.1	6.1	.6	135
Watermelons	1	58.0	39.0	.2		2.7	.1	55
Fruits, berries, etc., fresh.								
Apples	10	25.0	61.5	.4	.4	12.4	.3	255
Apricots	11	6.0	79.9	1.0		12.6	.5	255

[1] Refuse bran removed by sifting.

[2] Refuse pods.

Average composition of American food products—Continued.

Food materials (as purchased).	Number of analyses.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
VEGETABLE FOOD—continued.								
Fruits, berries, etc., fresh—Con.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Bananas	3	40.0	44.5	.7	.5	13.7	.6	290
Blackberries	1	....	88.9	.9	2.1	7.5	.6	245
Cherries, edible portion	1	....	86.1	1.1	.8	11.4	.6	235
Cranberries	2	....	88.5	.5	.7	10.1	.2	225
Grapes	4	25.0	59.1	1.0	1.3	13.3	.3	320
Huckleberries	1	....	82.4	.7	3.0	13.5	.4	390
Lemons	2	30.0	62.5	.7	.6	5.8	.4	145
Nectarines	1	6.6	77.4	.6	....	14.8	.6	285
Oranges	13	27.0	64.5	.6	.4	7.1	.4	160
Pears	1	25.0	62.9	.5	.6	10.6	.4	235
Pineapples, edible portion	1	....	89.3	.4	.3	9.7	.3	200
Plums	1	4.8	74.6	1.0	....	19.1	.5	370
Prunes, fresh	1	5.8	75.6	.7	....	17.4	.5	335
Raspberries	1	....	85.8	1.0	....	12.6	.6	255
Strawberries	19	10.0	81.8	.9	.6	6.1	.6	155
Fruits, dried and canned.								
Apples, dried	3	....	36.2	1.4	3.0	57.6	1.8	1,225
Apricots, dried	....	....	32.4	2.9	....	63.3	1.4	1,230
Blackberries, canned	1	....	40.0	.8	2.1	56.4	.7	1,150
Blueberries, canned	2	....	85.3	.6	.7	13.0	.4	280
Crab apples, canned	1	....	42.4	.3	2.4	54.4	.5	1,120
Dates, dried	1	12.0	18.3	1.9	4.5	61.9	1.4	1,375
Figs, dried	....	....	22.5	5.1	....	70.0	2.4	1,395
Peaches, canned	1	....	93.7	.5	.2	5.3	.3	115
Pineapples, canned	1	....	61.8	.4	.7	36.4	.7	715
Prunes, dried	....	15.0	22.4	2.0	.7	58.6	1.3	1,155
Raisins, dried	2	....	14.0	2.5	4.7	74.7	4.1	1,635
Zante currants	2	....	27.9	1.2	3.0	65.7	2.2	1,370
Nuts.								
Chestnuts, fresh	5	16.0	32.4	5.8	6.7	37.7	1.4	1,090
Chestnuts, dried	4	23.0	4.5	8.1	7.7	54.6	2.1	1,490
Cocoanut, prepared	2	....	3.5	6.3	57.4	31.5	1.3	3,125
Peanuts	4	33.0	6.2	17.3	25.9	16.3	1.3	1,718
Miscellaneous.								
Chocolate	1	....	10.3	12.5	47.1	26.8	3.3	2,720
Cocoa	3	....	4.6	21.6	28.9	37.7	7.2	2,320

METHODS OF CONTROLLING INJURIOUS INSECTS.

REMEDIES FOR IMPORTANT INSECTS.

ANGOUMOIS GRAIN MOTH (*Sitotroga cerealella* Oliv.). Prompt thrashing of grain after harvesting; bisulphide of carbon in bins and granaries.

APPLE-LEAF SKELETONIZER (*Canarsia hammondi* Riley). Spraying with arsenicals (paris green and london purple) in June; hand-picking of leaves with larvæ.

APPLE-ROOT PLANT-LOUSE (*Schizoneura lanigera* Hausm.). Kerosene emulsion under and above ground; scalding water poured freely about roots; bisulphide of carbon under ground about roots; ashes around trunk.

APPLE-TREE BORER, FLAT-HEADED (*Chrysobothris femorata* Fab.). Painting trunk and larger branches in June with strong soap solution, washing soda, or mixture of whitewash and paris green; placing bars of soap in crotches of trees, to be washed down by rain.

ARMY WORM (*Leucania unipuncta* Haw.). Burning over fields in winter; ditching; paris green.

ASPARAGUS BEETLE (*Crioceris asparagi* Linn.). Prompt marketing of all canes; dusting with lime; arsenical mixtures (paris green and london purple); jarring larvæ to ground on hot days, especially if soil be sandy.

BEAN WEEVIL (*Bruchus obtectus* Say). Treating with bisulphide of carbon in air-tight vessels.

BLISTER BEETLES (*Epicauta vittata* Fab., *E. cinerea* Lec., *E. pennsylvanica* DeG., *Macrobasis unicolor* Kb.). Arsenicals, 1 pound to 100 gallons of water.

Boll worm. (*See* Corn ear worm.)

Buffalo gnat (*Simulium pecuarum* Riley). Smudges; oil, grease, etc., applied to stock.

Cabbage bug, Harlequin (*Murgantia histrionica* Hahn). Spring collecting from trap mustard; hand-picking.

Cabbage worms (*Pieris rapæ* Sch., *Plutella cruciferarum* Zell., *Plusia brassicæ* Riley). Pyrethrum; kerosene emulsion; paris green, dry, with flour or lime—1 part of the poison in 50 to 100 of the diluent.

Cankerworm, Spring (*Paleacrita vernata* Peck). Arsenical mixtures in spray; trapping female moth in oil troughs or tar bands about trunk of trees.

Carpet beetle, or buffalo moth (*Anthrenus scrophulariæ* L.). Benzine; hot ironing of carpets over damp cloth; killing by steam.

Chinch bug (*Blissus leucopterus* Say). Burning wild-grass land and all rubbish in early winter; kerosene emulsion; contagious disease; trap crops; ditching.

Clothes moth, Southern (*Tinea bisselliella* Hum.). Airing and sunning; benzine; naphthaline; packing in paper bags.

Cockroach, German; Croton bug (*Phyllodromia germanica* L.). Pyrethrum or buhach; bisulphide of carbon in tight rooms or compartments away from fire.

Codling moth; Apple worm (*Carpocapsa pomonella* Linn.). Arsenicals; first application as soon as blossoms fall; second, one or two weeks later, just before the fruit turns down on the stem; trapping larvæ by applying bands to the tree; prompt destruction of infested fallen fruit.

Cotton worm (*Aletia xylina* Say). Paris green dusted on as dry powder.

Corn root-worm (*Diabrotica longicornis* Say). Rotation of corn with oats or other crop.

Cornstalk borer, Larger (*Diatræa saccharalis* F.). Plowing under or burning stubble.

Corn ear worm; Bollworm (*Heliothis armiger* Hbn.). Late fall plowing; poisoned baits; for cotton, planting corn as trap crop.

Currant worm, Imported (*Nematus ribesii* . . .). Hellebore, 1 ounce to 2 gallons water, in spray.

Cucumber beetle, Striped (*Diabrotica vittata* Fab.). Protecting young plants with netting; arsenicals.

Cutworms (Agrotis, Leucania, Mamestra, Hadena, Nephelodes, etc.). Distribution of poisoned green bait; late fall plowing; burning waste tracts and rubbish.

Elm leaf-beetle, Imported (*Galeruca luteola* Müll.). Arsenicals, 1 pound to 100 gallons water.

Flea-beetle, Striped (*Phyllotreta vittata* Fab.). Kerosene emulsion; arsenicals.

Fluted scale (*Icerya purchasi* Mask.). Introduction of its ladybird enemy, *Novius cardinalis;* hydrocyanic-acid-gas treatment; soap, 1 pound to 2 gallons hot water.

Fruit bark-beetle (*Scolytus rugulosus* Ratz.). Burning trap trees and infested trees at any time, but preferably in winter.

Grain weevils (*Calandra granaria* Linn., *C. oryza* Linn.). Bisulphide of carbon in bins and granaries.

Grape phylloxera (*Phylloxera vastatrix* Planch.). Submersion; bisulphide of carbon, kerosene emulsion, or resin compound about roots; use of resistant stocks.

Grapevine leaf-hopper (*Erythroneura vitis* Harr.). Spraying with kerosene emulsion in early morning; catching on tarred shield; cleaning up all leaves and rubbish in fall.

Gypsy moth (*Ocneria dispar* L.). Spraying with arsenicals; hand collecting of cocoons and eggs; poisoning egg masses; trapping larvæ.

Hessian fly (*Cecidomyia destructor* Say). Late planting; selection of wheat less subject to attack; rolling; pasturing to sheep; rotation of crops.

Hop plant-louse (*Phorodon humuli* Schr.). Destroying all wild plum trees in vicinity; spraying others in fall or spring with strong kerosene emulsion; spraying vines with kerosene emulsion or fish-oil soap; destroying vines after hops are picked.

Horn fly (*Hæmatobia serrata* R.-D.). Application of strong-smelling greases and oils to cattle, or of lime or plaster to dung.

Locust, California devastating (*Melanoplus devastator* Scudd.). Poisoned bait of bran, sugar, and arsenic.

Locust, Lesser migratory (*Melanoplus atlanis* Riley). (*See* Rocky Mountain locust.)

Locust, Red-legged (*Melanoplus femur-rubrum* DeG.). (*See* Rocky Mountain locust.)

LOCUST, ROCKY MOUNTAIN (*Melanoplus spretus* Thos.). Catching with hopper-dozers; ditching; burning; rolling; plowing under of eggs.

OX BOT (*Hypoderma lineata* Vill.). Strong-smelling fats and oils applied to cattle.

OYSTER-SHELL BARK-LOUSE (*Mytilaspis pomorum* Bouché). Kerosene emulsion; strong soap or alkali washes.

PEACH-TREE BORER (*Sannina exitiosa* Say). Cutting out the larvæ or scalding them with hot water in late autumn or early spring; painting trunk with arsenicals in thick whitewash; wrapping trunk with grass, paper, etc.

PEAR-TREE PSYLLA (*Psylla pyricola* Forst.). Kerosene emulsion: First, a winter application diluted seven times; second, in spring as soon as leaves are unfolded, diluted nine times.

PEAR-TREE SLUG (*Eriocampa cerasi* Peck.). Hellebore, 1 ounce to 2 gallons water in a spray; whale-oil soap, 12 pounds to 50 gallons water; arsenicals.

PEA WEEVIL (*Bruchus pisorum* Linn.). Keeping seed over to second year; bisulphide of carbon in tight vessels.

PLUM CURCULIO (*Conotrachelus nenuphar* Herbst). Arsenical spray: First, before the bloom appears or as soon as foliage starts; second, immediately after blossoms fall; third, a week or ten days after the last; collection of adults from trees by jarring.

POTATO BEETLE, COLORADO (*Doryphora 10-lineata* Say). Arsenicals, 1 pound to 100 gallons water.

PURPLE SCALE OF THE ORANGE (*Mytilaspis citricola* Pack.). Kerosene emulsion, applied immediately after appearance of new brood.

RICE WATER WEEVIL (*Lissorhoptrus simplex* Say). Draining.

ROSE CHAFER (*Macrodactylus subspinosus* Fab.). Planting spiræas, etc., as trap plants, and collecting beetles in special pans; arsenicals; kerosene emulsion.

SAN JOSE SCALE (*Aspidiotus perniciosus* Comst.). Soap wash (2 pounds to the gallon) as soon as leaves fall in autumn; in warm, dry climate, winter resin wash.

SCREW WORM (*Compsomyia macellaria* Fab.). Prompt burning or burying of dead animals; smearing wounds with fish oil; washing with carbolic acid.

SQUASH BORER (*Melittia ceto* Westw.). Planting early summer squashes to be destroyed; late planting of main crop; destruction of all vines attacked as soon as crop can be gathered; collecting moths.

SQUASH BUG (*Anasa tristis* DeG.). Early burning of vines and all rubbish in fall; biweekly collection of eggs.

STRAWBERRY WEEVIL (*Anthonomus signatus* Say). Trap crops; protecting beds with cloth covering; using staminate varieties as fertilizers only and as few plants of the former as necessary; spraying with paris green.

SUGAR-CANE BORER (*Diatræa saccharalis* Fab.). Burning trash and laying down seed cane under ground.

WEBWORM, FALL (*Hyphantria cunea* Dr.). Prompt removal and destruction of webs with larvæ; arsenical spraying.

WHEAT ISOSOMA (*Isosoma grande* Riley). Burning stubble; rotation of crops.

WHEAT PLANT LOUSE (*Siphonophora avenæ* Fab.). Rotation of crops.

WHITE GRUB; JUNE BEETLE (*Lachnosterna* spp.). Luring the beetles by lights over tubs into water with skim of kerosene. Against larvæ: Kerosene emulsion; liberal use of potash fertilizers; collecting after the plow.

WIREWORMS (*Drasterius elegans* Fab., *Melanotus fissilis* Say, and *Agriotes* spp.). Fall plowing; poisoned baits; rotation of crops.

PREPARATION AND USE OF INSECTICIDES.

ARSENICALS: PARIS GREEN AND LONDON PURPLE.—These two arsenicals practically take the place of all other insecticides for biting and gnawing insects living or feeding on the exterior of plants.

Paris green is a very fine crystalline powder, composed of arsenic, copper, and acetic acid.

London purple is a waste product in the manufacture of aniline dyes, and contains a number of substances, chief of which are arsenic and lime. It is not as effective as paris green and is apt to scald foliage unless mixed with lime. It costs about 10 cents a pound, while paris green costs twice as much.

Both these arsenicals may be used as follows:

The wet method.—Make into a thin paint a small quantity of water, adding powdered or quick lime equal to the amount of poison used. Strain the mixture into the spray tank. Use either poison at the rate of a pound of dry powder in from 100 to 200 gallons of water. The stronger mixtures are for resistant foliage, such as that of the potato, and the weaker for sensitive foliage, such as that of the peach and plum.

The dry method.—It is ordinarily advisable to use the poison in the form of a spray, but in the case of cotton and some other low crops it may be dusted on the plants. Make the application preferably in early morning or late evening, when the dew is on, to enable the poison to better adhere to the plant. In cotton fields the powder is usually dusted over the plants from bags fastened to each end of a pole which is carried on horse or mule back. The motion of the animal is sufficient to cause the distribution over the foliage. Garden vegetables may be dusted by hand from bags or powder bellows. For vegetables which are soon to be used as food, mix the poison with 100 times its weight of flour or lime, and apply merely enough to show evenly over the surface.

When to spray.—Spray for the codling moth very soon after the blossoms fall and again a week or two later, just before the fruit turns down on the stem. This treatment reaches at the same time other leaf-eating insects.

For the Curculio, spray as soon as the foliage is well started and again at the time of the exposure of the young fruit by the falling of the blossoms, and a third time a week later, particularly if rains have intervened after the last treatment.

For leaf-feeding insects, spray at the earliest indication of injury, and repeat as often as necessary.

Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honeybees or other insects useful as cross fertilizers.

ARSENATE OF LEAD.—This arsenical has advantages over paris green, in that it has the merit of showing on the leaves, indicating at once which have been sprayed; remains much more easily suspended in water, and may be used in large proportions without danger to foliage. The insecticide results are not better, however, than in the case of paris green; but for sensitive foliage, or where no risk of scalding may be taken, it will prove useful.

It is prepared by combining, approximately, 3 parts arsenate of soda with 7 parts acetate of lead. From 1 to 10 pounds arsenate of lead are used with 150 gallons of water, 2 quarts of glucose being added to cause it to adhere better to the leaves. From 2 to 5 pounds will answer for most larvæ. The arsenate of lead costs 7 cents a pound wholesale, and glucose $16 a barrel.

ARSENIC BAIT.—It is not always practicable to apply poison directly to plants, and in such cases the use of poison bait is valuable, particularly for cutworms, wireworms, and grasshoppers or locusts.

Bran-arsenic bait.—This is made by combining 1 part by weight of white arsenic, 1 of sugar, and 6 of bran, to which enough water is added to make a wet mash. For grasshoppers or locusts place a tablespoonful at the base of each tree or vine, or lay a line of it at the head of the advancing army, placing a tablespoonful every 6 to 8 feet, and following this up with another line in front of the first. For baiting cutworms distribute the mash in small lots over the infested territory.

Green bait.—For the destruction of cutworms and wireworms use preferably poisoned green succulent vegetation, such as freshly cut clover, distributing it in small bunches about the infested fields. The bunches of green vegetation should be dipped in a strong solution of arsenicals, and prevented from rapid drying by being covered with stones or boards. Renew as often as the bait becomes dry.

In the use of poison bait care must be exercised against its being eaten by domestic animals.

CARBON BISULPHIDE.—This substance, used in tight receptacles, is the cheapest and most effective remedy for all insects affecting stored food and seed material, natural-history specimens, etc., and is one of the best means against insects affecting the roots of plants in loose soils. It is a colorless liquid, with an offensive odor, which soon passes off. It readily volatilizes, and is deadly to insect life. The vapor is highly inflammable and explosive, and should be carefully kept from fire, even a lighted cigar in its proximity being a source of danger. Wholesale, it costs 10 cents a pound; retail, of druggists, 25 to 30 cents a pound.

For root lice of grape, apple, etc., put one-half ounce of bisulphide into holes about plants 10 to 16 inches deep, 1½ feet apart, and not closer to trunk than 1 foot. Make the holes with iron rod and close with foot, or use hand injectors. For root maggots put a teaspoonful into a hole 2 or 3 inches from the plant and close immediately. For ant nests pour an ounce of the liquid into each of several holes in the nests; close the openings with the foot or cover with a wet blanket for ten minutes, and then explode the vapor at mouth of holes with torch.

For stored-grain insects distribute in shallow dishes over the bins; with open bins cover with oilcloth or blankets to retain the vapor. Keep bins or buildings closed for from twenty-four to thirty-six hours; then air them well. Disinfect infested grain in small bins before placing for long storage in large masses.

The bisulphide is applied at the rate of 1 pound to the ton of grain.

HELLEBORE.—White hellebore is used extensively as an insecticide, particularly as a substitute for the arsenites. It kills insects in the same way as an internal poison. It is less dangerous to man and the higher animals than the arsenical poisons, but if sufficient quantity be taken it will cause death. It is particularly useful against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application is preferably made in the evening, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

In most instances where hellebore is used, the same results may be more cheaply accomplished by using either a soap solution or the arsenicals.

HYDROCYANIC ACID GAS.—This substance is chiefly used to destroy scale insects on fruit trees and nursery stock. The treatment consists in inclosing the tree or nursery stock with a tent and filling the latter with the poisonous gas.

The tents should be of blue or brown drilling, or 8-ounce duck, painted or oiled to make air-tight. The tent may be placed over small trees by hand and over large trees with a tripod or derrick. A tent and derrick for medium-sized trees cost from $15 to $25; for a tree 30 feet tall by 60 feet in circumference, about $60.

Fused potassium cyanide (58 per cent pure), commercial sulphuric acid, and water are used in generating the gas, the proportions being 1 ounce by weight of the cyanide, slightly more than 1 fluid ounce of acid, and 3 fluid ounces of water to every 150 cubic feet of space inclosed.

Place the generator (any glazed earthenware vessel of 1 or 2 gallons' capacity) on the ground within the tent, and add the water, acid, and cyanide, the latter in lumps, in the order named. Allow one-half hour for large trees or fifteen minutes for small ones. Bright, hot sunlight is apt to cause injury to foliage and may be avoided by working on cloudy days or at night. One series of tents will answer for a county or large community of fruit growers.

KEROSENE.—Kerosene, or coal oil, is occasionally used directly against insects, although its important insecticide use is in combination with soap or milk emulsion. Under exceptional conditions it may be sprayed directly on living plants, and it has been so used in the growing season without injury. Ordinarily, however, when applied even in the dormant season on leafless plants, it is liable to do serious injury or to kill the plant outright. It is now being used to a certain extent mechanically combined with water in the act of spraying, and is less harmful in this way than when used pure, as it is broken up more finely and somewhat distributed; but the danger of use on tender plants is not avoided by this means.

Many insects which can not be destroyed by ordinary insecticides may be killed by jarring them from the plants into pans of water on which a little kerosene is floating, or they may be shaken from the plants onto cloth or screens saturated with kerosene.

For the mosquito, kerosene has proved a very efficient preventive. Applied, at the rate of an ounce to 15 square feet, to the surface of small ponds or stagnant water in which mosquitoes are breeding, it forms a uniform film over the water and destroys all forms of aquatic insects, including the larvæ of the mosquito and the adult females which come to the surface of the water to deposit their eggs. The application retains its efficiency for several weeks.

KEROSENE EMULSIONS.—The kerosene emulsions apply to all such sucking insects as plant bugs, plant lice, scale insects, thrips, and plant mites, and to such biting insects as can not be safely poisoned.

Kerosene and soap emulsion formula.

Kerosene	gallons	2
Whale-oil soap (or 1 quart soft soap)	pounds	1–2
Water	gallon	1

Dissolve the soap in water by boiling, and add boiling hot, away from the fire, to the kerosene. Agitate violently for five minutes by pumping the liquid back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. The mixture will have increased about one-third in bulk, and assume the consistency of cream. Well made, the emulsion should keep indefinitely, and should be diluted only as wanted for use.

In limestone or hard-water regions "break" the water with lye before using to make or dilute the emulsion, or use rainwater. Better than either, use the milk emulsion, with which the character of the water does not affect the result.

The kerosene and milk emulsion formula.

Heating is unnecessary; churn as in the former case for three to five minutes, or until a thick, buttery consistency results. Prepare the milk emulsion from time to time for immediate use, unless it can be stored in air-tight jars; otherwise it will soon ferment and spoil.

How to use the emulsions.—For summer applications for most plant lice and other soft-bodied insects, dilute with 15 to 20 parts of water; for the red spider and other plant mites, the same, with the addition of 1 ounce of powdered sulphur to the gallon; for scale insects, the larger plant bugs, larvæ, and beetles, dilute with 7 to 9 parts water.

For subterranean insects, such as root lice, root maggots, "white grubs," etc., use either kerosene emulsion or resin wash, wetting the soil to the depth of 2 to 3 inches, and follow with copious waterings, unless in rainy season.

NAPHTHALINE.—This substance is used principally for the repellant action due to the vapor it exhales at the ordinary temperature of the air. In the form of cubes, cones, or globes it is used to protect clothing from the ravages of moths. Placed with stored-seed products it will protect them from various weevils and stored-grain pests. It has no effect on the germination of the seed. Naphthaline is also quite universally employed to preserve natural-history specimens from museum pests. The vapors of naphthaline are fatal to insects, but the vapor of bisulphide of carbon is much quicker in action, and to be preferred.

OILS: FISH OIL, TRAIN OIL, AND COTTON-SEED OIL.—These are sometimes used on domestic animals to rid them of vermin, and fish oil is one of the best-known repellants for the horn fly, buffalo gnat, and ox bot fly. Any of these oils or any grease, the more strong smelling the better, thinly smeared on animals at the points of attack by flies, will afford great protection. They are also valuable against lice affecting live stock, but must be used carefully or they may cause the hair to fall off.

PYRETHRUM, OR INSECT POWDER.—This insecticide is sold under the names of buhach and Persian insect powder.

It acts on insects externally, through their breathing pores, and is fatal to many forms. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of poisons would be inadvisable.

It is used as a dry powder, pure or diluted with flour, when it may be puffed about rooms or wherever insects may occur. When used on plants, it is preferably applied in the evening. As a preventive, and also as a remedy for the mosquito, burning the powder in a tent or room will give satisfactory results. It may also be used as a spray, at the rate of 1 ounce to 3 gallons of water, but in this case should be mixed up some twenty-four hours before being applied. For immediate use a decoction may be prepared by boiling in water from five to ten minutes.

RESIN WASH.—This is valuable for scale insects wherever the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and as winter washes in very mild climates, as southern California, or wherever the multiplication of the insect continues almost without interruption throughout the year.

Formula for resin wash.

Resin	pounds	20
Caustic soda (70 per cent)	do	5
Fish oil	pints	2½
Water to make	gallons	100

Ordinary commercial resin is used, and the soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (93 per cent) used, 3¾ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances with the oil in the kettle, with water to cover them to a depth of 3 or 4 inches. Boil from one to two hours, occasionally adding water, until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed, the mixture should be perfectly fluid and without sediment, and should any appear in the stock mixture reheating should be resorted to. For a winter wash dilute one-third or one-half less.

SOAPS AS INSECTICIDES.—Any good soap is effective in destroying soft-bodied insects, such as plant lice and young or soft-bodied larvæ. The soaps made of fish oil, and sold under the name of whale-oil soaps, are especially valuable. For plant lice and delicate larvæ, such as the pear slug and others, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. Soft soap will answer as well as hard, but at least double quantity should be taken.

As winter washes the fish-oil soaps have proved the most effective means of destroying certain scale insects, and have been of especial service against the very resistant San Jose scale.

For winter applications, use the soap at the rate of 2 pounds to a gallon of water, making the application with a spray pump as soon as the leaves fall in the autumn, repeating, if necessary, in spring before the buds unfold.

SULPHUR.—Flowers of sulphur is one of the best remedies for plant mites, such as the the "red spider," six-spotted orange mite, rust mite of the orange fruit, etc. Applied at the rate of 1 ounce to a gallon of water, or mixed with some other insecticide, such as kerosene emulsion, it is a very effective remedy. For the rust mite, sprinkling the powdered sulphur about under the trees is sometimes sufficient to keep the fruit bright. Sulphur is often used to rid poultry houses of vermin, and when fed to cattle is said to be a good means of ridding them of lice; or it may be mixed with grease, oil, etc., and rubbed into the skin.

Bisulphide of lime.—This chemical is even better than sulphur as a remedy for mites, but it is a liquid and can be diluted easily to any extent. It can be made very cheaply by boiling together in a small quantity of water equal parts of lime and flowers of sulphur. For mites, take 5 pounds of sulphur and 5 of lime, and boil in a small quantity of water until both are dissolved and a brownish liquid results. Dilute to 100 gallons.

TAR.—This substance is commonly used as a repellant by dissolving in water and sprinkling the plants with the solution. It is also sometimes smeared in and about the nostrils of sheep, to prevent the bot fly from depositing its eggs. Painted on paper bands wrapped around the bases of fruit trees, and renewed before becoming dry, it will entrap the wingless female cankerworm moths in their attempts to ascend the trees for the purpose of depositing eggs. Pine tar is preferable to coal tar, but neither kind should be applied directly to the bark. A prepared grease, known as insect lime, is now generally employed instead of tar.

A CHEAP ORCHARD-SPRAYING OUTFIT.

Spraying to control various insect pests, particularly those of the orchard and garden, has reached so satisfactory and inexpensive a basis that it is recognized by every progressive farmer as a necessary feature of the year's operations, and in the case of the apple, pear, and plum crops the omission of such treatment means serious loss. The consequent demand for spraying apparatus has been met by all the leading pump manufacturers of this country, and ready-fitted apparatus, consisting of pump, spray tank or barrel, and nozzle with hose, are on the market in numerous styles and at prices ranging from $20 upward. The cost of a spraying outfit for orchard work may, however, be considerably reduced by purchasing merely the pump and fixtures and mounting them at home on a strong barrel. An apparatus of this sort, representing a style that has proved very satisfactory in practical experience, is illustrated in the accompanying figure. It is merely a strong pump with an air-chamber to give a steady stream provided with two discharge hose pipes. One of these enters the barrel and keeps the water agitated and the poison thoroughly intermixed, and the other and longer one is the spraying hose and terminates in the nozzle. The spraying hose should be about 20 feet long and may be fastened to a light pole, preferably of bamboo, to assist in directing the spray. The nozzle should be capable of breaking the water up into a fine mist spray, so as to wet the plant completely with the least possible expenditure of liquid. A suitable pump with nozzle and hose may be obtained of any hardware dealer.

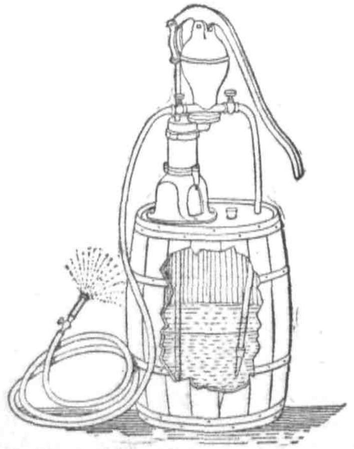


FIG. 134.—Orchard-spraying apparatus.

TREATMENT FOR FUNGOUS DISEASES OF PLANTS.

In the following table the plants affected are arranged alphabetically, and in columns opposite each name are given the number of times and methods of making the various treatments. Following the names of the fungicides are small numbers, which refer to the formulas for making them. The formulas follow the table:

Disease.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Remarks.
Almond or apricot shot-hole fungus.	Ammoniacal copper carbonate solution (1) when leaves unfold.	Same fungicide ten or twelve days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later, if necessary.	....	
Apple scab..........	Bordeaux mixture (2), 60-gallon formula, when fruit buds are unfolding.	Same fungicide when flower clusters are expanding.	Same fungicide when petals are falling.	Same fungicide when fruit is one-half inch in diameter, if wet weather prevails.	Same fungicide two weeks later, if wet weather prevails.	Paris green may be combined with the fungicide in a proportion of 4 ounces to every 50 gallons of the mixture to prevent ravages of codling moth.
Barley smut	Soak seed in cold water four hours.	Place in sacks and leave for four hours.	Soak seed in water at a temperature of 126° to 128° for five minutes.	....	....	
Cherry leaf blight..	Bordeaux mixture (2), 60-gallon formula, after foliage is fully developed.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	A sixth application may be necessary. The treatment is especially applicable to nursery stock, and the endeavor should be made to keep the upper and lower surfaces of the newly developing foliage covered with the fungicide.
Cherry and plum black knot.	Bordeaux mixture (2), 22-gallon formula, before leaves appear.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	....	The knots should be cut off and burned whenever possible. Painting the cut surfaces with kerosene or linseed oil will tend to prevent the return of the knots.
Grape black rot	Bordeaux mixture (2), 50-gallon formula, before buds open.	Same fungicide when leaves are one-third grown.	Same fungicide just before blooming.	Same fungicide two weeks later.	Ammoniacal copper carbonate solution (1), two weeks later.	A sixth application may be necessary, and it should be made with ammoniacal copper carbonate solution. In dry weather it is probable that the number of sprayings may be less.
Grape downy mildew.	Bordeaux mixture (2), 60-gallon formula, when leaf buds open.	Same fungicide when leaves are half grown.	Same fungicide when plants are in bloom.	Same fungicide when fruit is half grown.	....	As this disease and black rot frequently occur together, the same applications will generally answer for both. If more than four applications be made, as may be necessary in wet seasons, ammoniacal copper carbonate solution should be used to prevent spotting the fruit.

TREATMENT FOR FUNGOUS DISEASES OF PLANTS—Continued.

Disease.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Remarks.
Oat smut	Soak seed for one minute in warm water at 110° (4).	Soak seed in hot water at 132° for ten minutes.				After the second soaking, if not needed for immediate use, the seed should be spread out to dry and then put in clean bags, which have been previously sterilized by heat.
Orange sooty mold	Resin wash (5) in January or February.	Same wash ten days to two weeks later.	Same wash in May or August.			Special care should be taken to wet the under surfaces of the leaves. Usually, two sprayings in winter are sufficient.
Peach curl	Bordeaux mixture (2) 50-gallon formula, just before buds unfold.	Same fungicide when leaves are half grown.	Same fungicide two weeks later.	Same fungicide two weeks later.		
Pear leaf blight	Bordeaux mixture (2) 50-gallon formula, when buds are swelling.	Same fungicide when leaves are half grown.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later	This is especially for the nursery. In the orchard the first and second treatments may be omitted.
Pear scab	Bordeaux mixture (2) 50-gallon formula, when fruit buds open.	Same fungicide just before blossoming.	Same fungicide when petals fall.	Same fungicide when fruit is one-half inch in diameter.		
Plum, prune, and peach leaf rust.	Ammoniacal copper carbonate solution (1) when trees cease to bloom and when in leaf.	Same fungicide three weeks later.	Same fungicide two weeks later.			
Potato rot or blight and Macrosporium disease.	Bordeaux mixture (2), 22-gallon formula, when plants are 6 inches high.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.		For best results potatoes should be dug as soon as plants wither, not allowing them to remain in the ground until cold weather.
Potato scab	Cut and soak potatoes in corrosive sublimate solution (6) one hour and thirty minutes.					
Quince fruit spot and leaf blight.	Bordeaux mixture (2), 60-gallon formula, after blossoms fall.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	A sixth application may be necessary in case of very wet weather.
Wheat stinking smut.	Soak seed for one minute in warm water at 110°–115° (4).	Soak seed for fifteen minutes in hot water (132°)	Cool seed with cold water and spread out to dry.			

FORMULAS FOR FUNGICIDES.

(1) *Ammoniacal copper carbonate solution:*

Copper carbonate	ounces	5
Ammonia (26 per cent)	pints	3
Water	gallons	50

Place the copper carbonate in a wooden pail and make a paste of it by the addition of a little water. Then pour on the ammonia and stir until all the copper is dissolved. If the 3 pints of ammonia is not sufficient to dissolve the copper, add more until no sediment remains. Pour into a barrel and dilute with 45 or 50 gallons of water, and the mixture is then ready for use.

(2) *Bordeaux mixture:*

Copper sulphate	pounds	6
Strong fresh lime	do	4
Water	gallons	22

In a barrel that will hold 45 gallons dissolve the copper sulphate, using 8 or 10 gallons of water, or as much as may be necessary for the purpose. In a tub or half barrel slack the lime. When completely slacked, add enough water to make a creamy whitewash. Pour this slowly into the barrel containing the copper sulphate solution, using a coarse gunny sack stretched over the head of the barrel for a strainer. Finally, fill the barrel half full of water, stir thoroughly, and the mixture is ready for use. The 50 or 60 gallon formula is made in the same way, except that 50 or 60 gallons of water is added instead of 22 gallons. For further directions in making large quantities see Bulletin No. 6, Division Vegetable Physiology and Pathology, pp. 8–11.

(3) *Potassium sulphide:*

Potassium sulphide	ounces	2½
Water	gallons	5

Dissolve the potassium sulphide in water, and the mixture is ready for use.

(4) *Hot-water treatment:*

This treatment is used for smuts of oats and wheat. Place two large kettles or two wash boilers on a stove; provide a reliable thermometer, and a coarse sack or basket for the seed. A special vessel for holding the grain may be made of wire or perforated tin. The vessel should never be entirely filled with grain, and in the kettles there should be about five or six times as much water by bulk as there is grain in the basket. In the first kettle keep the temperature of the water at from 110° to 130°, and in the other at 132° to 133°, never letting it fall below 130° lest the fungous spores may not be killed, nor rise above 135° lest the grain be injured. Place the grain in the basket and then sink it into the first kettle. Raise and lower it several times or shake it so that all the grain may become wet and uniformly warm. Remove it from the first kettle and plunge it into the second, where it should receive fifteen minutes' treatment. Shake about repeatedly, and also raise the basket containing the grain completely out of the water five or six times during the treatment. If the temperature falls below 132°, let the basket remain a few moments longer; if it rises, a few moments less. Have at hand cold and boiling water with which to regulate the temperature. At the expiration of fifteen minutes remove the grain and plunge into cold water, after which spread it out to dry. The seed may be sown at once, before thoroughly dry, or may be dried and stored until ready for use. In treating oats keep them in water at 132° for only ten minutes and spread out to dry without plunging into the cold water.

(5) *Resin wash:*

Resin	pounds	20
Caustic soda (98 per cent)	do	4½
Fish oil (crude)	pints	3
Water to make	gallons	15

Place the resin, caustic soda, and fish oil in a large kettle. Pour over them 13 gallons of water and boil until the resin is thoroughly dissolved, which requires from three to ten minutes after the materials begin to boil. While hot add enough water to make just 15 gallons. When this cools, a fine, yellowish precipitate settles to the bottom of the vessel. The preparation must therefore be thoroughly stirred each time before measuring out to dilute, so as to uniformly mix the precipitate

with the clear, dark, amber-brown liquid, which forms by far the greater part of the stock preparation. When desired for use, take 1 part of the stock preparation to 9 parts of water. If the wash be desired for immediate use, the materials, after boiling and while still hot, may be poured directly into the spray tank and diluted with cold water up to 150 gallons.

(6) *Corrosive sublimate solution:*

Corrosive sublimate	ounces	2¼
Water	gallons	15

This solution is used for potato scab. The corrosive sublimate is dissolved in about 2 gallons of hot water, and after an interval of ten or twelve hours diluted with 13 gallons of water. The potatoes to be planted are immersed in the solution for one and one-half hours, after which they are spread out to dry, then cut and planted as usual. A half barrel is a convenient receptacle for the solution. The potatoes may be put into a coarse sack and suspended in the liquid, first washing the tubers. Corrosive sublimate is very poisonous and should be kept out of the way of children and animals. All treated tubers should be planted or destroyed.

ERRONEOUS IDEAS CONCERNING HAWKS AND OWLS.

Much misapprehension still exists among farmers as to the habits of birds of prey. Examination of the contents of the stomachs of such birds, to the number of several thousand, has established the fact that their food consists almost entirely of injurious mammals and insects, and that accordingly these birds are in most cases positively beneficial to the farmer, and should be fostered and protected.

Among those *wholly beneficial* are the large, rough-legged hawk; its near relative, the squirrel hawk, or ferruginous roughleg, and the four kites—the white-tailed kite, Mississippi kite, swallow-tailed kite, and everglade kite.

The class that is *beneficial in the main*—that is, whose depredations are of little consequence in comparison with the good it does—includes a majority of the hawks and owls, among them being the following species and their races: Marsh hawk, Harris's hawk, red-tailed hawk, red-shouldered hawk, short-tailed hawk, white-tailed hawk, Swainson's hawk, short-winged hawk, broad-winged hawk, Mexican black hawk, Mexican goshawk, sparrow hawk, Audubon's caracara, barn owl, long-eared owl, short-eared owl, great gray owl, barred owl, Western owl, Richardson's owl, Acadian owl, screech owl, flammulated screech owl, snowy owl, hawk owl, burrowing owl, pygmy owl, ferruginous pygmy owl, and elf owl.

The class in which the *harmful and the beneficial* qualities about balance each other includes the golden eagle, bald eagle, pigeon hawk, Richardson's hawk, Aplomado falcon, prairie falcon, and great horned owl.

The *harmful* class comprises the gyrfalcons, duck hawk, sharp-shinned hawk, Cooper's hawk, and goshawk.

The investigations upon which the foregoing statements are based were described at considerable length in the Department's Yearbook for 1894.

TIMBER—LUMBER—WOOD.

QUALITY.

Sapwood is light and weak if from an old tree, but heavy and strong if from a young tree.

Sapwood shrinks more and decays more easily than heartwood.

A young tree makes heavier and stronger wood than an old tree, hence second growth is often better than old timber.

The butt cut of hard pine weighs 20 per cent more and is 30 per cent stronger than the top cut.

The heaviest stick of the same kind, when seasoned, is the strongest; a piece of seasoned pine weighing 45 pounds to the cubic foot is one-third to one-half stiffer and stronger than one weighing 30 pounds.

Broad-ringed oak and pine, with broad, dark bands of summer wood, are strongest.

Crossgrain and knots reduce both stiffness and strength.

A crossgrained piece will scarcely support one-twentieth of the load that a straight-grained piece of the same kind will support.

EFFECTS OF SEASONING.

A cord of green wood weighs 50 per cent more than when air dry.

A cord of well-dried wood still contains 600 pounds of water.

In the burning of green wood, nearly one-half the heat is lost in evaporating the water contained in it.

One-half the weight of fresh, sappy pine is due to water. The kiln-drying of lumber, at a small expense, saves 1,000 to 1,500 pounds of freight per 1,000 feet, B. M.

Seasoning increases stiffness and strength by about 50 per cent.

Checks produced in drying decrease the value of timber; seasoning, therefore, always injures as well as benefits.

Wood always swells and shrinks—that is, takes up and gives off water—hence the periodic recurrence of cracks in floors, etc.

Split wood shrinks more evenly, sheds water and wears better than if sawed.

Good hard pine shrinks about 6 inches per 100 inches width of flooring when laid green; good red oak about 9 inches.

A "quarter-sawed" board shrinks only one-half to two-thirds as much as a bastard-sawed one.

Wood shrinks inappreciably in length, 3 to 6 per cent in radial direction (across the rings), and 4 to 10 *per cent in tangential direction (with the rings)*.

Quarter-sawed boards and bastard-sawed boards neither shrink nor wear alike; hence they should not be used side by side for best floors.

STIFFNESS AND STRENGTH.

Doubling the length of a board or timber reduces the stiffness eightfold and the strength one-half.

Doubling the width of a board doubles the stiffness and strength.

Doubling the thickness of a board or the depth of a timber increases the stiffness about eightfold and the strength fourfold.

If, therefore, it is desired to double the length and retain the same stiffness, it is necessary to double the thickness or depth.

Weight for weight, a stick of pine is stronger and stiffer than a solid iron or steel of same shape.

A joist 2 by 6 inches is three times as stiff as one 2 by 4.

A joist 2 by 8 inches is eight times, and one 2 by 12 is twenty-seven times, as stiff.

A good hard pine joist 2 by 4 inches and 10 feet long may support 2,000 pounds in the middle, but it can safely be trusted only to the extent of 400 pounds.

If loaded suddenly, a timber bends much more than if loaded gradually with the same load.

A timber projecting from the wall and loaded at the end (a cantilever) supports only as much as a timber twice the length resting on both ends and loaded in the middle.

MEASUREMENT.

A cord of body wood closely piled contains 100 cubic feet of solid wood; if one-third limbs, not more than 80 cubic feet.

A cord of good oak wood contains 175 to 200 billets, requires about a dozen small-sized trees (8 to 10 inches diameter) or one good-sized tree (20 to 24 inches) to make it, and weighs about 2 tons.

To obtain, approximately, the volume of a standing tree, measure the circumference breast-high, square it, divide by 25, and multiply by the estimated height. For saw timber, take estimated length of log instead of height of tree.

To obtain volume of standing timber per acre, count and classify trees of same diameter and height, measure one of each class, multiply by the number of trees in the class, and add the results.

Summary of log-book estimates for memorizing.

Diameter of log in inches	10	12	14	16	18	20	22	24
Number of feet, B. M., contained in 10 feet of length	20	40	60	90	120	160	200	250
Difference in feet	20	20	30	30	40	40	50	

It will be observed that the increase in diameter from 10 inches to 12 and from 12 inches to 14 is accompanied, in each case, by an increase of 20 feet in the contents of the log; that the increase from 14 inches to 16 and from 16 inches to 18 is accompanied, in each case, by an increase of 30 feet in the contents of the log,

and that the increase from 18 inches to 20 and from 20 inches to 22 represents, in each case, an addition of 40 feet to the contents of the log. The reader can follow out this ratio of increase as circumstances require.

DISTANCE TABLE FOR TREE PLANTING.

Number of trees that may be set upon a piece of land 100 yards or feet square on a side, in right-angled rows of equal and unequal distances apart.

Yds. or ft. between trees in the rows.	Yards or feet between rows.														
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	9.0	10.0
0.5	20,000	13,333	10,000	8,000	6,667	5,714	5,000	4,444	4,000	3,636	3,333	2,857	2,500	2,222	2,000
1.0	10,000	6,667	5,000	4,000	3,333	2,857	2,500	2,222	2,000	1,818	1,666	1,428	1,250	1,111	1,000
1.5	6,667	4,444	3,333	2,667	2,222	1,905	1,667	1,481	1,333	1,212	1,111	952	833	740	666
2.0	5,000	3,333	2,500	2,000	1,667	1,429	1,250	1,111	1,000	909	833	714	625	555	500
2.5	4,000	2,667	2,000	1,600	1,333	1,143	1,000	889	800	727	666	571	500	444	400
3.0	3,333	2,222	1,667	1,333	1,111	952	833	741	667	606	555	476	416	370	333
3.5	2,857	1,905	1,429	1,143	952	816	714	635	571	519	476	408	357	317	285
4.0	2,500	1,667	1,250	1,000	833	714	625	556	500	455	416	357	312	277	250
4.5	2,222	1,481	1,111	889	741	635	556	494	444	404	370	317	277	246	222
5.0	2,000	1,333	1,000	800	667	571	500	444	400	364	333	285	250	222	200
5.5	1,818	1,212	909	727	606	519	455	404	364	333	303	259	227	202	181
6.0	1,667	1,111	833	667	556	476	417	370	333	303	277	238	208	185	166
6.5	1,538	1,026	769	615	513	440	385	342	308	280	256	219	192	170	153
7.0	1,429	952	714	571	476	408	357	317	286	260	238	204	178	158	142
7.5	1,333	889	667	533	444	381	333	296	267	242	222	190	166	148	133
8.0	1,250	833	625	500	417	357	313	278	250	227	208	178	156	138	125
8.5	1,176	784	588	471	392	336	294	261	235	219	196	168	147	130	117
9.0	1,111	741	556	494	370	317	278	247	222	202	185	158	138	123	111
10.0	1,000	667	500	400	333	286	250	222	200	100	166	142	125	111	100

In order to find number of trees needed per acre divide the above figures by 2, if they have been read as referring to feet; multiply them by $4\frac{1}{8}$ if they have been read as referring to yards. This will give the number needed within an unappreciable error.

TWO HUNDRED WEEDS: HOW TO KNOW THEM AND HOW TO KILL THEM.

The following table presents the common and technical names of 200 weeds, which seem to be those that are most troublesome in the United States. It does not include all the plants which are deservedly classed as weeds, but omits many which are less aggressive, or only locally abundant and troublesome. A few of the species, such as Bermuda grass, Johnson grass, crab grass, and sweet clover, are valuable for forage, but are so tenacious of life and so prolific as to become persistent weeds in cultivated land. Some of the species ranking among the worst weeds could doubtless be made useful. False flax and some of the mustards contain valuable oils; burdock, curled dock, dandelion, pokeweed, and purslane are good pot herbs, while many species have a market value as medicinal plants that would at least compensate in part for the labor expended in cutting or destroying them.

Common names.—The first common name given in each instance is regarded as the best for general use.

Technical names.—Technical names in italics indicate native species; those in capitals, introduced species.

Duration.—The duration of life in a weed is of special importance as affecting methods of eradication. A few species which are perennial in the Southern States are killed by the severe winters in the North and there become annuals. Some that are biennials or winter annuals in the Central States are strictly annual in the colder Northern States. The duration in the region where the weed is most troublesome is here indicated.

Where injurious.—In this column is indicated the region where a species is most injurious, and not its complete geographical distribution. For example, the brake or eagle fern is found in every State, but is really troublesome as a weed only in the States of the Pacific Coast.

Time of flowering and time of seeding.—The seasons of flowering and seeding vary considerably in different latitudes. The dates here given are intended to cover the region where the species is most troublesome.

Color, size, and arrangement of flowers.—The most prominent color and the approximate diameter of a single flower, or of a head in the case of composites, are given.

Methods of propagation and distribution of seed.—Nearly all weeds are reproduced abundantly by seeds, and their spread is effected almost exclusively by these, or by bulblets or spores which perform the same office. But some are propagated also by runners, roots, bulbs, or rootstocks, and a knowledge of these methods is important for determining methods of eradication. Only the natural means or the most important artificial methods of distribution can here be given.

Place of growth and products injured.—The places mentioned indicate under what conditions the plant occurs as an injurious weed. Nearly all weeds abound in waste places, along roadsides and in vacant lots, where they grow unmolested and produce seeds to propagate themselves in fields and gardens. Only the crops or products that are especially injured can be given here, as a complete catalogue of the injuries produced by a single species would in some instances cover almost the entire list of agricultural productions.

Methods of eradication.—The trouble and expense of weed eradication may in many cases be avoided by the use of pure seed in the operations of the farm or garden. Especial care should be exercised in regard to those weed seeds which are indicated as distributed in grass, grain, or clover seeds. Annual weeds seldom thrive in strong sod and they are choked down by dense crops of grain, clover, or cowpeas. Therefore, as a matter of prevention, land not in use should be seeded with forage or soil-renovating crops, while cornfields, potato fields, and gardens should where practicable be covered during fall, winter, and spring with crops of winter wheat, rye, or crimson clover. To put a stop to the production of seeds is a necessary part of the process of eradication. An average full-grown plant of button weed produces about 1,500 seeds; of pennycress, about 5,000 to 10,000; of prickly lettuce, 8,000 to 15,000, and a medium-sized Russian thistle about 20,000, while a single plant of purslane has been estimated to bear 1,250,000 seeds. Weeds bearing mature seed should be burned and under no circumstances plowed under. Most weed seeds will retain their vitality several years in the ground, and when buried at different depths by the plow some are likely to germinate and produce plants each year for ten years or longer. If the land is cultivated shallow first, then successively deeper so as to bring all the seeds near the surface, they will be induced to either germinate or decay. In most cases this work can be done as well with hoed crops as with summer-fallow.

Biennials and winter annuals may be eradicated by cutting the root below the crown with a spud, hoe, or plow. Mowing biennial plants at frequent intervals will destroy them, but an occasional mowing usually induces them to branch low and send up several stalks which, if not cut, will come to maturity and produce seeds.

The roots or rootstocks of perennial weeds may be killed by the following methods: (1) They may be dug up and removed, a remedy that can be practically applied only in small areas. (2) They may be killed by applying chemicals either to the freshly cut root or at the base of the main stem. Salt, strong brine, coal oil, crude sulphuric acid, and carbolic acid have been successfully used for this purpose. A few drops of carbolic acid applied at the base of the main stem with an ordinary machine-oil can is the best method that has yet been devised for killing weeds with chemicals. (3) Rootstocks or perennial roots may be starved to death by preventing any development of green leaves or other parts above ground. This may be effected by building straw stacks over small patches, by persistent, thorough cultivation in fields, by the use of the hoe or spud in waste places, and by salting the plants and turning on sheep in permanent pastures. (4) The plants may usually be smothered by dense sod-forming grasses or by a crop like clover or millet that will exclude the light. (5) Most rootstocks are readily destroyed by exposing them to the direct action of the sun during the summer drought, or to the direct action of the frost in winter. In this way plowing, for example, becomes effective. (6) Any cultivation which merely breaks up the rootstocks and leaves them in the ground, especially during wet weather, only multiplies the plant and is worse than useless, unless the cultivation is continued so as to prevent the growth above ground. Plowing and fitting corn ground in April and May, and cultivating at intervals until the last of June, then leaving the land uncultivated during the remainder of the season, is one of the best methods that could be pursued to encourage the growth of couch grass, Johnson grass, and many other perennial weeds.

Table of two

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Barnyard grass, barn grass, cocksfoot, water grass.	*Panicum crusgalli;* Old World; annual.	Wisconsin to Montana.	June to August.	July to September.
Beggar ticks, bur marigold, pitchforks, stick seed.	Bidens frondosa; eastern United States; annual.	New England to Texas.	July to September.	September to November.
Bermuda grass, dogstooth grass, scutch grass, wire grass.	*Capriola dactylon;* Tropics; perennial.	Virginia to Texas.	July to October.	Does not seed in United States.
Big root, man-in-the-ground, wild gourd.	Megarrhiza oregona; Pacific Coast; perennial.	Washington to California.	April to May.	September to November.
Bindweed, bear bind, English bindweed, morning glory.	*Convolvulus arvensis;* Old World; perennial.	New England to Texas, Utah, and California.	June to September.	August to November.
Bitter dock, broad-leaved dock, yellow dock.	*Rumex obtusifolius;* Europe; perennial.	New England to Wisconsin.	July to August.	September to November.
Black mustard, brown mustard, grocers' mustard.	*Brassica nigra;* Europe; annual.	New England to California.	June to September.	July to November.
Bladder ketmia, flower-of-an-hour, good-night at-noon.	*Hibiscus trionum;* Old World; annual.	Michigan to Illinois.	July to September.	September to November.
Blue vervain, simpler's joy.	Verbena hastata; eastern United States; perennial.	New England to Wisconsin.	June to September.	August to November.
Boneset, ague weed, fever weed, thoroughwort.	Eupatorium perfoliatum; eastern United States; perennial.	New England to Illinois.	July to September.	September to December.
Bouncing Bet, hedge pink, soapwort.	*Saponaria officinalis;* Europe; perennial.	....do....	....do....	September to November.
Bracted plantain, Western plantain.	Plantago aristata; prairie States; perennial.	Ohio to Kansas.	June to December.	July to December.
Branched broom rape, broom rape.	*Orobanche ramosa;* southern Europe; annual.	Kentucky and Illinois.	June to August.	July to September.
Broom sedge, sedge grass, Virginia beard grass.	Andropogon virginicus; southeastern United States; perennial.	Maryland to Texas.	July to August.	August to September.
Broom weed, flaxweed..	Gutierrezia sarothræ; prairie States; perennial.	Kansas to Texas.	July to September.	August to November.
Buffalo bur, beaked horse nettle, Rocky Mountain sand bur, sand bur, spiny nightshade.	Solanum rostratum; Rocky Mountains; annual.	Illinois to Colorado.	June to August.	....do....
Bugseed	Corispermum hyssopifolium; central United States; annual.	Wisconsin to Nebraska and Oregon.	August to September.	September to November.
Bull nettle, horse nettle, blue top, trompillo.	Solanum elæagnifolium; southern United States; perennial.	Kansas to New Mexico.	July to September.	August to October.
Bull thistle, bird thistle, boar thistle, pasture thistle.	*Carduus lanceolatus;* Europe; biennial.	New England to Kansas.	June to July.	July to September.
Bur clover, toothed medick.	*Medicago denticulata;* Old World; annual or biennial.	Washington to Arizona.	May to June.	....do....
Burdock, beggar's buttons, gobo, great dock.	*Arctium lappa;* Europe; biennial.	New England to Wisconsin and Texas.	July to September.	August to October.
Bur grass, bear grass, hedgehog, Rocky Mountain sand bur, sand bur, sandspur.	Cenchrus tribuloides; eastern United States; annual.	In sheep-raising localities in all States.	May to October.	June to November.
Bur ragweed, rosetilla..	Gærtneria acanthicarpa; western United States; annual.	Minnesota to California.	August to September.	September to October.
Button weed, compass weed, poor weed.	Diodia teres; southeastern United States; annual.	Maryland to Texas.	July to September.	August to November.

hundred weeds.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
Green; ⅛ inch; panicle.	Seeds; in grain seed and by wind.	Moist soil, fields; spring wheat.	Prevention of seeding; use of clean seed; improved drainage.
Yellow; ⅛ inch; head.	Seeds; by animals...	Moist soil, pastures; hoed crops.	Prevention of seeding; improved drainage.
Purple; 1/12 inch; spikes.	Rootstocks carried by cultivating tools and in nursery stock.	Sandy soil; hoed crops.	Repeated plowing to expose rootstocks to frost, or to the sun in dry weather.
White; ¼ inch; racemes.	Seeds; roots........	Sandy soil; cultivated crops.	Repeated spudding; killing roots with salt, coal oil, or carbolic acid.
White; 1 inch; solitary.	Seeds; rootstocks; grain and hay.	Sandy soil; grain and hoed crops.	Frequent spudding; thorough cultivation; application of coal oil or carbolic acid.
Green; ⅛ inch; racemes.	Seeds; clover seed...	Cultivated land and pastures; all crops.	Frequent spudding; thorough cultivation with hoed crops.
Yellow; ¼ inch; panicle.	Seeds; in grass, clover, and grain seed.	Cultivated fields; grain and clover.	Hand pulling while in flower; cultivation with hoed crops.
White; 1 inch; solitary.	Seeds; blown by wind from flower gardens.	Cultivated fields; grain and hoed crops.	Prevention of seeding in flower gardens; late summer cultivation.
Blue; ⅛ inch; spike.	Rootstocks; seeds; hay, clover, and grass seeds.	Low land; pastures; grain and hoed crops.	Repeated cutting in pastures; thorough cultivation.
White; ⅛ inch; heads in clusters.	Seeds; carried by the wind.	Low land; pastures..	Repeated cutting in July and August.
Pink; 1 inch; cymes.	Seeds; rootstocks; escape from gardens.	Roadsides, lawns, and fields; pastures and grain crops.	Prevention of seeding in gardens and waste places; cultivation.
Green; ¼ inch; spike.	Seeds; in clover and grass seed.	Pastures and grain fields; pastures and grain.	Mowing or cultivation to prevent seeding; spudding in lawns.
White or purple; ¼ inch; spike.	Seeds; with seeds or stems of hemp and tobacco.	Parasitic on roots of hemp and tobacco.	Cultivating other crops in infested fields; burning stems of tobacco or hemp from infested fields.
Green; ¼ inch; racemes in clusters.	Roots, seeds; seeds carried by wind.	Worn-out fields; grain and hoed crops.	Increased fertilization; summer cultivation; seeding with clover or cowpeas.
Yellow; ¼ inch; heads in cymes.	.....do..............	Roadsides and fields; pastures and hoed crops.	Prevention of seeding; cultivation; reseeding worn-out pastures.
Yellow; ½ inch; solitary.	Seeds; by wind as a tumbleweed, in baled hay, and by animals.	Open fields; grain and hoed crops, wool.	Prevention of seeding; burning mature plants; cultivation with hoed crops.
Green; ⅛ inch; spikes.	Seeds; by wind as a tumbleweed.	Sandy land; grain and hoed crops.	Prevention of seeding; burning mature plants.
Purple; 1 inch.	Roots, seeds; in hay and grain.	River valleys and plains; grain and hoed crops.	Repeated spudding; cultivation with hoed crops; coal oil or salt.
Purple; 2 inches; head.	Seeds; wind.........	Cultivated fields and meadows; grain and hay.	Spudding in fall; summer cultivation; repeated mowing.
Yellow; ¼ inch; raceme.	Seeds; carried by animals and in alfalfa seed.	Pastures and grain fields; wool, grain.	Burning mature plants; cultivation.
Purple; ½ inch; head.	Seeds; carried by animals.	Pastures, fence rows, grainfields; wool, grain.	Repeated spudding, or mowing; burning mature plants.
Green; ⅛ inch; bur.	.....do..............	Sandy pastures, sheep trails, sheep-washing places; wool, pastures.	Cultivation; hoeing or burning plants about sheep-washing yards.
Yellow; ¼ inch; heads in racemes.	Seeds; burs carried by animals.	Sheep trails and overfed sheep ranges; wool.	Summer cultivation; mowing or burning plants.
Purple; ⅓ inch; in pairs, axillary.	Seeds; in grain and clover seed.	Cultivated fields; hoed crops.	More thorough cultivation; seeding with winter annuals after corn and potatoes.

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Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Callirrhoe, poppy mallow.	Callirrhoe involucrata; prairie States; perennial.	Nebraska to Texas.	June to September.	July to November.
Canada thistle, creeping thistle, cursed thistle.	*Carduus arvensis;* Europe; perennial.	New England to Missouri and Washington to California.	June to August.	July to September.
Caraway, garden caraway.	*Carum carui;* Europe; biennial.	New England..	June to July.	......do ....
Careless weed, pigweed.	*Amaranthus hybridus;* tropical America; annual.	New Jersey to Texas.	July to September.	August to October.
Carpet weed, Indian chickweed.	*Mollugo verticillata;* Tropics; annual.	......do	May to September.	June to November.
Catnip, catmint, catnep.	*Nepeta cataria;* Old World; perennial.	New England to Michigan.	June to September.	August to November.
Chainy brier, bamboo, china brier, saw brier.	Smilax glauca; eastern United States; perennial.	Pennsylvania to Tennessee.	June to July	July to September.
Charlock, wild mustard, yellow mustard.	*Brassica sinapistrum;* Europe; annual.	New England to Oregon.	May to August.	June to September.
Chess, cheat, wheat thief, Willard's brome grass.	*Bromus secalinus;* southern Europe; annual.	In all grain-raising regions.	June to July.	July to August.
Chicory, succory	*Cichorium intybus;* Europe; perennial.	New England to Alabama and in California.	July to September.	September to November.
Chickweed, common chickweed.	*Alsine media;* Europe; annual or winter annual.	New England to Texas and California.	January to December.	February to December.
Chondrilla, devil's greens, gum succory, hog bite, skeleton weed.	*Chondrilla juncea;* Europe; biennial.	West Virginia, Maryland, and Virginia.	June to September.	July to October.
Climbing false buckwheat, bindweed.	Polygonum scandens; northern United States; perennial.	New York to Minnesota.	June to August.	July to September.
Clover dodder, devil's gut, dodder.	*Cuscuta epithymum;* Europe; annual.	All States where red clover or alfalfa is grown.	June to November.	July to November.
Cocklebur, clot bur	Xanthium canadense; northern United States; annual.	All States	June to September.	August to December.
Corn cockle, bastard nigella, cockle, rose campion.	*Agrostemma githago;* Europe; annual.	All wheat-raising States.	May to July..	July to August.
Cornflower, bachelor's button, bluebottle, French pink.	*Centaurea cyanus;* southern Europe; annual.	Atlantic and Pacific States.	July to September.	September to November.
Corn gromwell, field gromwell, pigeon weed, red root, stone seed, wheat thief.	*Lithospermum arvense;* Europe; annual.	New York to Michigan.	May to July..	July to August.
Couch grass, devil's grass, durfee grass, quack grass, quick grass, witch grass.	Agropyron repens; northern United States; perennial.	New England to Minnesota.	July to August.	August to September (seldom seeds).
Cow herb, cockle, cow basil, cow fat, glond.	*Saponaria vaccaria;* Europe; annual.	Colorado to California and Washington.	June to July.	July to August.
Cow parsnip, masterwort.	Heracleum lanatum; northern United States; perennial.	New England to Iowa.	July to August.	August to November.
Crab grass, finger grass, Polish millet.	*Panicum sanguinale;* Old World; annual.	New Jersey to Wisconsin and southward.	June to September.	July to October.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
Red or purple; 2 inches; solitary.	Seeds	Cultivated fields; grain and meadows.	Cultivation throughout the summer; repeated spudding or mowing.
Purple; ¾ inch; head.	Running roots, seeds; seeds carried by wind.	Cultivated fields; grain, pastures, meadows, and muck-land crops.	Frequent grubbing or mowing; plowing three times in August; salting the plants and pasturing sheep on them; application of kerosene or carbolic acid.
White; ⅛ inch; umbels.	Seeds; escaped from gardens.	Cultivated fields and meadows; grain, hay, flour.	Prevention of seeding in gardens; cultivation; hand pulling in grain fields.
Green; 1 line; spikes in panicles.	Seeds: in clover, grain, and grass seed, and in hay.	Cultivated fields; corn, potatoes, cotton.	Late summer cultivation; burning seed-bearing plants before plowing.
White; 1 line; in umbel-like axillary clusters.	Seeds; in grass seed; blown over snow.	Cultivated ground; hoed crops.	Summer cultivation; sowing winter annuals after corn, potatoes, and cotton.
Purple; ¼ inch; crowded spikes.	Rootstocks; seeds; in hay and grass seed.	Sandy soil; hay and grain.	Repeated mowing in July and August; cultivation.
Green; ¼ inch; umbels.	Tuberous roots carried by cultivating tools; seeds carried in hay and grain.	Meadows; cultivated land; hay, grain, hoed crops.	Thorough cultivation with hoed crops; repeated grubbing
Yellow; ½ inch; racemes.	Seeds; in clover, grass, and grain seed.	Grain fields and meadows; spring wheat, oats, barley, and clover.	Hand pulling in grain fields; cultivation with hoed crops.
Green; 1 line; spikelets in panicles.	Seeds; in grain seed.	Grain fields; wheat, oats, and barley.	Cultivation with hoed crops; cleaner seed grain.
Blue; 1 inch; head.	Seeds and roots; escaped from cultivation.	Grain fields and gardens; grain and hoed crops.	Prevention of seeding in gardens; repeated grubbing; cultivation with hoed crops.
White; ⅙ inch; cymose.	Seeds; blown over snow and carried in grass seed.	Moist soil, orchards, vineyards, lawns, and gardens.	Seeding with winter annuals; early spring cultivation; reseeding lawns.
Yellow; ¼ inch; heads.	Seeds; blown by wind.	Worn-out fields; pastures, grain.	Cultivation with hoed crops and increased fertilization; spudding or mowing.
Green; ¼ inch; panicles.	Seeds, and roots; seeds carried in grain and clover seed.	Moist land, grain	Cultivation with hoed crops; use of cleaner grain seed.
Yellow; ⅛ inch; clusters.	Seeds; in clover and alfalfa seed.	Clover and alfalfa fields; clover and alfalfa hay and seed.	Use of clean seed; burning small patches; cultivating other crops in infested fields.
Green; ½ inch; head.	Seeds; burs carried by animals.	Fence rows, pastures, and meadows; wool.	Cultivation; burning mature plants before plowing.
Purple; 1 inch; solitary.	Seeds; in grain seed.	Grain fields; wheat, flour.	Use of clean seed; hand pulling; cultivation with hoed crops.
Blue; 1 inch; heads.	Seeds; in grass and grain seeds; from gardens.	Pastures, lawns, grain fields.	Prevention of seeding in flower gardens; repeated spudding; cultivation.
Purple; ½ inch; axillary.	Seeds; in grain seed.	Grain fields; wheat.	Use of clean seed; burning wheat stubble in infested fields.
Green; 1 line; spike.	Rootstocks carried by cultivating tools; seeds in hay.	Fields; all crops except hay.	Repeated plowing in July and August, followed by heavy seeding with rye.
Pink; ¾ inch; cyme.	Seeds; in grain and alfalfa seed.	Fields; grain	Use of clean seed; hand pulling in grain; cultivation.
White; ⅛ inch; umbel.	Seeds; blown over snow.	Low meadows and pastures; hay and pastures.	Repeated mowing or grubbing; cultivation.
Green; ⅛ line; spikes.	Seeds; grass seed and hay.	Gardens; hoed crops and lawns; hoed crops, orchards.	Cultivation; hand pulling in lawns.

Table of two hundred

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Creeping bur ragweed, franseria.	Gærtneria discolor; Rocky Mountains; perennial.	Wyoming to New Mexico.	June to August.	July to September.
Curled dock, sour dock, yellow dock.	*Rumex crispus;* Europe; perennial.	All States except Southeastern.	June to September.	July to October.
Daisy fleabane, sweet scabious, white top.	Erigeron annuus; eastern United States; annual.	Maine to Minnesota and southward.	June to August.	July to September.
Dandelion	*Taraxacum taraxacum;* Europe; biennial.	All States	May to October.	May to November.
Devil weed, golden hawkweed, king devil, paint brush.	*Hieracium præaltum;* Europe; perennial.	New York	June to September.	July to September.
Dog fennel, mayweed, stinking chamomile.	*Anthemis cotula;* Europe; annual.	In all States	June to August.	do
Drop-seed dock, sorrel dock.	Rumex hastatulus; southern United States; perennial.	South Carolina to Florida.	May to July	June to August.
Eagle fern, bracken, brake.	Pteris aquilina; cosmopolitan; perennial.	Pennsylvania, Washington to California.		
Evening primrose	Œnothera biennis; eastern United States; biennial.	New England to Wisconsin and southward.	June to August.	September to December.
False flax, gold of pleasure, Siberian oilseed, wild flax.	*Camelina sativa;* Europe; annual or biennial.	Ohio to North Dakota.	May to September.	July to November.
Fetid marigold, stinkweed.	Dyosodia papposa; central United States; annual.	Nebraska to Texas.	July to September.	September to November.
Field peppergrass, English peppergrass, Mithridate mustard, yellowseed.	*Lepidium campestre;* Europe; annual.	New England to Michigan.	May to July	May to August.
Fireweed	Erechtites hieracifolia; northern United States; annual.	Pennsylvania to Wisconsin.	June to August.	July to September.
Five finger, Norway cinquefoil.	Potentilla monspeliensis; northern United States; perennial.	Ohio to Minnesota.	do	do
Galingale, sedge	Cyperus phymatodes; central United States; perennial.	New Jersey to Michigan and southward.	do	do
Giant ragweed, hogweed, horseweed, tall ragweed.	Ambrosia trifida; eastern United States; annual.	New York to North Dakota and southward.	July to September.	August to November.
Green pigeon grass, bottle grass, green foxtail.	*Setaria viridis;* Old World; annual.	Ohio to Iowa and southward.	do	August to October.
Ground cherry, lance-leafed ground cherry.	Physalis lanceolata; central United States; perennial.	Illinois to Kansas.	do	August to November.
Gum plant, rosinweed, sunflower.	Grindelia squarrosa; prairie States; perennial.	Minnesota to Montana and southward.	do	do
Hedge bindweed, bracted bindweed, devil's vine, Rutland beauty, wild morning-glory.	Convolvulus sepium; northern United States; perennial.	New Jersey to Iowa.	July to October.	September to December.
Hedge mustard	*Sisymbrium officinale;* Europe; annual or biennial.	New England to Ohio and southward.	May to September.	July to October.
Hen bit, dead nettle	*Lamium amplexicaule;* Europe; annual.	New England to West Virginia.	April to June.	May to July
Hogweed	Bœrhaavia erecta; Texas; annual.	Texas to Louisiana.	June to November.	July to December.
Horse nettle, bull nettle, radical, sand brier.	Solanum carolinense; southeastern United States; perennial.	New Jersey to Iowa and southward.	June to September.	August to December.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
Yellow; $\frac{1}{4}$ inch; heads.	Seeds, carried by sheep; rootstocks, carried by cultivating tools.	Meadows, pastures, grain fields; wool and all crops.	Thorough cultivation in dry weather; burning mature plants.
Green; $\frac{1}{8}$ inch; panicle.	Roots, seeds in hay and grain; blown over snow.	Meadows and grain-fields; all crops.	Alternate cultivation and heavy cropping; mowing or grubbing in pastures.
White; $\frac{3}{8}$ inch; heads.	Seeds; in hay, clover, and grass seed.	Meadows and grain-fields.	Cultivation with hoed crops; mowing early.
Yellow; 1 inch; head.	Seeds; carried by wind.	Meadows, pastures, and lawns.	Cultivation; repeated spudding in lawns.
Yellow; $\frac{1}{2}$ inch; head.	Running rootstocks; seed carried by wind.	Meadows and pastures.	Cultivation; salting plants in sheep pastures.
White; $\frac{3}{4}$ inch; head.	Seeds; in hay and grass seed.	Roadsides, meadows, pastures.	Mowing roadsides, mowing or cultivating fields.
Greenish white; $\frac{1}{4}$ inch; panicle.	Seeds, by wind and in grass seed; running rootstocks.	Meadows and pastures.	Cultivation with hoed crops; early mowing in meadows.
Flowerless	Rootstocks; spores; carried by wind.	Recently cleared land, pastures and meadows.	Alternate cultivation and heavy cropping.
Yellow; 1 to 2 inches; spikes.	Seeds; carried by wind.	Sandy land; meadows; grain and hoed crops.	Cultivation in fall or spring; burning mature plants; repeated mowing.
Yellow; $\frac{1}{2}$ inch; racemes.	Seeds; carried in flaxseed, clover and grass seed.	Sandy land; flax and grain.	Cultivation in autumn; pulling or mowing plants in bloom.
Yellow; $\frac{1}{2}$ inch; heads.	Seeds; carried in hay and by winter winds.	Meadows and pastures.	Cultivation with hoed crops.
White; 1 line; crowded racemes.	Seeds; in hay, clover, and grass seed.	Sandy land; meadows, grain.	Thorough cultivation with hoed crops; increased fertilization.
Purple; $\frac{1}{4}$ inch; heads in panicles.	Seeds; carried by wind.	Recently cleared land, cultivated marshes; grain, marsh-land crops.	Hand pulling or cutting in early summer.
Yellow; $\frac{1}{4}$ inch; solitary.	Running rootstocks; seeds.	Cultivated marshes; onions, peppermint, and celery.	More thorough cultivation.
Green; $\frac{1}{4}$ line; spikes in umbels.	Tubers carried by cultivating tools; seeds carried in grass seed and hay.	Moist land; meadows, pastures, and lowland crops.	Repeated spudding; frequent cultivation throughout the season; thick seeding with timothy or redtop.
Yellow; $\frac{1}{4}$ inch; racemes.	Seeds; carried by water and blown over snow.	Moist or sandy land; meadows and pastures.	Heavy seeding or cultivation; mowing young plants or burning mature ones.
Green; 1 line; spikes.	Seeds; in clover and grass seed.	Meadows and grain fields.	Cultivation throughout the season with hoed crops.
Yellow; 1 inch; racemes.	Running roots; seeds.	Sandy land; meadows; grain and hoed crops.	More thorough cultivation
Yellow; $\frac{1}{2}$ inch; heads.	Roots; seeds	Meadows and pastures.	Repeated mowing; cultivation.
White; 2 inches; solitary.	Running roots; seeds.	Rich prairie soil; corn and grain.	Burning seed-bearing plants before plowing; late cultivation in hoed crops.
Yellow; $\frac{1}{3}$ inch; racemes.	Seeds; in clover and grass seed and hay.	Dry fields; pastures and grain.	Cultivation with hoed crops; increased fertilization.
Purple; $\frac{1}{4}$ inch; axillary whorls.	Seeds; running rootstocks.	Moist lawns, pastures, and meadows.	Spudding or hand pulling in lawns; cultivation with hoed crops.
White; $\frac{1}{16}$ inch; cyme.	Seeds; in grass and grain seed and hay.	Rich bottom lands; meadows, and hoed crops.	Thorough cultivation; heavy seeding.
Purple; 1 inch; raceme.	Running roots; seeds in hay and clover seed.	Meadows, pastures, and cultivated land; all crops.	Alternate cultivation and heavy cropping; repeated spudding; application of carbolic acid.

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Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Horseweed, butterweed, colt's tail, fleabane.	Erigeron canadense; eastern United States; annual.	In all States	July to September.	August to October.
Hound's-tongue, dog bur, wool mat.	*Cynoglossum officinale;* Europe; biennial.	New England to Wisconsin.	June to August.	July to September.
Indian mallow, American jute, butter print, stamp weed, velvet leaf.	*Abutilon abutilon;* India; annual.	Ohio to Iowa	July to September.	August to November.
Indian tobacco, asthma weed.	Lobelia inflata; eastern United States; annual.	New England to Virginia.	July to November.	August to December.
Ironweed	Vernonia noveboracensis; eastern United States; annual.	Pennsylvania to Iowa.	July to September.	September to November.
Jimson weed, Jamestown weed, purple thorn apple.	*Datura tatula;* Tropics; annual.	Pennsylvania to Texas.	do	September to December.
Joe-Pye weed, trumpetweed.	Eupatorium purpureum; eastern United States; annual.	Pennsylvania to Missouri.	August to September.	September to November.
Johnson grass, Australian millet, Cuba grass, evergreen millet, Means grass.	*Andropogon halepensis;* Old World; perennial.	North Carolina to Texas and California.	June to August.	July to September.
Knot grass, doorweed, goose grass.	Polygonum aviculare; cosmopolitan; annual.	In all States	June to November.	July to December.
Lamb's quarters, goosefoot, pigweed.	*Chenopodium album;* Old World; annual.	do	July to November.	August to December.
Live-forever, Aaron's rod, garden orpine.	*Sedum telephium;* Europe; perennial.	New York and Pennsylvania.	July to August.	August to September.
Loco weed	Astragalus mollissimus; Rocky Mountains; perennial.	Montana to New Mexico.	June to August.	July to September.
Low amaranth, prostrate amaranth, spreading amaranth.	Amaranthus blitoides; prairie States; annual.	Minnesota to Texas.	July to September.	August to October.
Low hop clover	*Trifolium procumbens;* Europe; annual.	New England to Ohio.	June to September.	June to October.
Marsh elder, false ragweed, false sunflower, high-water shrub.	Iva xanthiifolia; Rocky Mountains; annual.	Minnesota to Idaho and southward.	August to September.	September to November.
Mexican poppy, devil's fig, prickly poppy, thistle poppy, yellow poppy.	*Argemone mexicana;* West Indies; annual or biennial.	Florida to California.	July to October.	do
Mexican tea, American wormseed.	*Chenopodium ambrosioides;* tropical America; annual.	Maryland to Texas.	August to November.	September to December.
Milfoil, yarrow	Achillea millefolium; cosmopolitan; perennial.	New England to Missouri.	June to August.	July to September.
Milk purslane, spotted spurge.	Euphorbia maculata; North America; annual.	In all States	May to November.	June to December.
Milk thistle, holy thistle, our lady's thistle.	*Silybum marianum;* Europe; annual.	California	June to July.	July to September.
Milkweed, silkweed, wild cotton.	Asclepias syriaca; northeastern United States; perennial.	New York to Wisconsin.	June to August.	July to October.
Morning-glory	*Ipomœa purpurea;* tropical America; annual.	Delaware and California.	July to October.	September to November.
Moth mullein	*Verbascum blattaria;* Europe; biennial.	New York to Iowa.	June to September.	July to December.
Motherwort	*Leonurus cardiaca;* Europe; perennial.	New England to Michigan.	June to August.	July to September.
Mouse barley, wall barley, wild barley.	*Hordeum murinum;* Europe; annual.	California	May to July.	June to July.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
White; ¼ inch; heads in cymes.	Seeds; carried by wind and in hay.	Meadows and grain fields.	Mowing; cultivation; burning stubble before plowing.
Purple; ¼ inch; racemes.	Seeds; carried by sheep.	Sheep pastures; wool.	Spudding, pulling, or repeated mowing early in the season.
Yellow; ⅛ inch; solitary.	Seeds; in clover seed; blown over snow.	Sandy fields; grain and hoed crops.	Thorough cultivation with hoed crops; burning mature plants before plowing.
Blue; ¼ inch; racemes.	Seeds; in hay and grass seed; pods blown over snow.	Meadows, pastures, and grain-fields; poisonous.	Cultivation; increased fertilization; hand pulling in meadows and pastures.
Purple; ⅛ inch; heads.	Perennial roots; seeds carried by wind.	Meadows and pastures.	Cultivation with hoed crops; frequent mowing.
Purple; 3 inches; solitary.	Seeds; pods blown over snow in winter.	Waste ground, pastures, neglected gardens.	Cutting while in flower; cultivation.
Purple; ¼ inch; heads in cymes.	Running roots; seeds carried by wind.	Moist or sandy meadows and pastures.	Cultivation with hoed crops; frequent mowing or spudding.
Green; ⅛ inch; panicle.	Running rootstocks, seeds; in hay and grass seed.	Moist or sandy land; all crops except hay.	Close grazing induced by salting the plants; alternate cultivation and heavy cropping; plowing to expose roots to frost or hot sun.
Pink; 1 line; axillary.	Seeds; blown over snow.	All places where turf has been broken.	Increased fertilization; thorough cultivation with hoed crops.
Green; 1 line; panicle.	Seeds; in grain and grass seed.	Grainfields and neglected cornfields.	Thorough cultivation with hoed crops.
Purple; ⅛ inch; cyme.	Tubers; carried by cultivating tools.	Slaty hills; all crops.	Infection with fungous disease; close grazing by sheep induced by salting the plants.
Violet; ⅓ inch; spikes.	Perennial roots; seeds.	Dry prairies; poisonous to stock.	Cultivation; repeated spudding.
Green; 1 line; spikes.	Seeds; in clover seed.	Broken land; neglected hoed crops.	*Late cultivation with hoed crops;* seeding land not in use.
Yellow; 1 line; heads.	Seeds	Sterile soil; neglected gardens.	Increased fertilization; cultivation or seeding.
Green; ¼ inch; heads.	Seeds; blown over snow, and carried by streams.	Rich prairie land; all crops.	Repeated mowing; cultivation; burning seed-bearing plants before plowing.
Yellow; 3 inches; solitary.	Seeds; carried by wind.	Neglected gardens and fields; poisonous if eaten.	Repeated mowing; cultivation.
Green; 1 line; panicle.	Seeds; blown by winds in winter.	Fields and neglected gardens; all crops.	Thorough cultivation; increased fertilization; seeding land not in use.
White; ¼ inch; heads in umbels.	Perennial roots, seeds, clover, and grass seeds.	Meadows, pastures, and grainfields.	*Cultivation; mowing* while in blossom.
Red; 1 line; axillary clusters.	Seeds	Broken land; all crops.	Thorough cultivation; heavy seeding.
Red or purple; 2 inches; heads.	Seeds; carried by wind.	Broken land; meadows and grain.	Mowing when the first blossoms appear; burning mature plants.
Purple; ½ inch; umbels.	Running rootstocks; seeds carried by wind.	Rich soil; all crops..	Mowing while in blossom; alternate cultivation and heavy cropping.
Purple to white; 1½ inches; solitary.	Seeds; escaped from gardens.	Cultivated fields	Prevention of seeding; thorough cultivation.
Yellow or white; 1 inch; racemes.	Seeds; in hay, clover, and grass seed.	Meadows and pastures.	Spudding in autumn; pulling or cutting while in flower; cultivation.
Purple; ½ inch; axillary clusters.	Running rootstocks; seeds.	Sandy land; meadows and gardens.	Cultivation.
Green; ⅓ line; spikes.	Seeds; hay, sheep, and wind.	Sandy pastures; awns injurious to mouths of animals.	Cultivation; heavy seeding; burning mature plants before plowing.

Table of two hundred

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Mouse ear cress	*Stenophragma thaliana*; Europe; winter annual.	Maryland to Tennessee.	April to May	May to June.
Mullein, Aaron's rod, black mullein, flannel plant, velvet dock.	*Verbascum thapsus*; Europe; biennial.	Maine to Wisconsin and southward.	July to September.	August to November.
Musky alfilerilla, ground needle, musky heronbill.	*Erodium moschatum*; Europe; annual.	California to Arizona.	April to November.	May to December.
Napa thistle, Malta thistle, tocalote.	*Centaurea melitensis*; Europe; annual.	California	do	do
Narrow-leafed stickseed.	*Lappula lappula*; Europe; annual.	New England to Minnesota and southward.	June to August.	July to October.
Narrow-leafed vervain, low vervain.	Verbena angustifolia; eastern United States; perennial.	Ohio to Alabama.	May to September.	do
Neckweed, purslane speedwell.	Veronica peregrina; cosmopolitan; annual.	New Jersey to Texas and California.	May to July	June to August.
Nightshade, black-berried nightshade.	Solanum nigrum; cosmopolitan; annual.	Maryland to Arkansas.	May to September.	June to October.
Nonesuch, black medick, medicago.	*Medicago lupulina*; Old World; annual.	New England and Florida to the Mississippi River.	June to September.	July to October.
Nut grass, coco, coco sedge, nut sedge.	*Cyperus rotundus*; Tropics; perennial.	Virginia to Texas.	July to September.	August to November.
Orange hawkweed, devil's paint brush, golden hawkweed, ladies' paint brush.	*Hieracium aurantiacum*; Europe; perennial.	Vermont to Ohio.	June to August.	June to September.
Oxeye daisy, bull's eye, sheriff pink, white daisy, white weed.	*Chrysanthemum leucanthemum*; Europe; perennial.	Maine to Virginia and Ohio.	May to July	July to September.
Paraguay bur	*Acanthospermum brasilum*; Brazil; annual.	North Carolina to Florida.	March to December.	May to January.
Paroquet bur	Sida stipulata; southeastern United States; annual or perennial.	Alabama to Florida.	June to November.	July to December.
Partridge pea	Cassia chamæcrista; southeastern United States; annual.	Virginia to Florida.	July to August.	August to November.
Passion flower, May pop.	Passiflora incarnata; southeastern United States; perennial.	North Carolina to Florida.	July to September.	do
Penny cress, French weed, Sargent weed.	*Thlaspi arvense*; Europe; annual.	Ohio, Minnesota, and North Dakota.	April to November.	June to December.
Peppergrass	Lepidium virginicum; eastern United States; annual.	New England to Wisconsin and southward.	May to July	June to August.
Perennial ragweed	Ambrosia psilostachya; central United States; perennial.	Minnesota to Texas and Arizona.	June to September.	July to October.
Perennial sow thistle, field sow thistle, sow thistle.	*Sonchus arvensis*; Europe; perennial.	New York to Wisconsin.	June to July.	July to August.
Pigeon grass, pussy grass, summer foxtail.	*Setaria glauca*; Old World; annual.	In every State.	June to September.	July to October.
Pigweed, redroot, rough amaranth.	*Amaranthus retroflexus*; tropical America; annual.	In nearly every State.	July to September.	August to November.
Pimpernel, poison chickweed, poor man's weather glass.	*Anagallis arvensis*; Europe; annual.	Atlantic States and California.	May to September.	May to October.
Plantain, white man's foot.	Plantago major; North America; perennial.	New England to Michigan.	June to September.	July to October.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
White; 1/8 inch; racemes.	Seeds	Meadows and pastures.	Early spring cultivation; heavy seeding with winter annuals.
Yellow; 3/4 inch; spike.	Seeds; in hay and clover seed.	Meadows, pastures, and winter grain-fields.	Spudding in autumn; pulling or cutting in grain and clover.
Pink; 1/4 inch; umbels.	Seeds; in hay, and carried by animals.	Rich soil; pastures, and all crops.	Cultivation with hoed crops; heavy seeding.
Yellow; 1 inch; heads.	Seeds; carried by wind.	Pastures; meadows and all crops.	Spudding or repeated mowing as often as heads appear; cultivation.
Blue; 1/2 inch; racemes.	Seeds; carried by animals.	Everywhere; all crops, wool.	Cultivation with hoed crops; burning or mowing grain stubble soon after harvest.
Purple; 1/4 inch; spikes.	Running rootstocks	Dry or sandy land; meadows and pastures.	Cultivation; repeated mowing.
Blue; 1/3 inch; axillary.	Seeds	Moist land; lawns and marsh crops.	Cultivation.
White; 1/4 inch; umbel-like clusters.	do	Moist or rich sandy land.	Cultivation; cutting before the berries mature.
Yellow; 1/6 inch; spikes.	Seeds; in hay and clover seed.	Sterile soil	Increased fertilization; seeding with clover or cowpeas.
Green; 1/2 line; spikes in umbels.	Tubers carried in nursery stock; seeds carried in hay and grass seed.	All soils; hoed crops.	Thorough cultivation alternating with heavy crops of cowpeas or Japan clover.
Orange; 1/2 inch; heads.	Roots, runners; seeds carried by wind and in clover seed; escape from gardens.	Sandy land; meadows and all crops.	Close grazing by sheep induced by salting plants; alternate cultivation and heavy cropping; prevention of seeding in gardens.
White; 1 inch; heads.	Perennial roots; seeds; in clover seed and hay.	Meadows and pastures.	Mowing early in June; cultivation with hoed crops.
Yellow; 1/4 inch; heads.	Seeds; carried by animals.	Cultivated land; hoed crops.	Cultivation; burning mature plants before plowing; heavy seeding.
Yellow; 1 inch; solitary or in clusters.	Seeds; carried by animals.	Cultivated land; hoed crops, wool.	Cultivation.
Yellow; 1 inch; racemes.	Seeds	Sandy fields; corn, *cotton*, and potatoes.	More thorough cultivation; destroying plants in flower; burning mature ones before plowing.
Purple; 2 inches; solitary.	Seeds; perennial roots.	Sandy fields; hoed crops.	Alternate cultivation and heavy seeding with cowpeas.
White; 1/8 inch; racemes.	Seeds; in clover seeds; pods blown by wind.	Rich, sandy land; all crops, flour, beef, and dairy products.	Thorough cultivation with hoed crops; burning mature plants before plowing.
White; 1 line; racemes.	Seeds; in hay, clover, and grass seed.	Sandy fields; all crops.	Increased fertilization; burning plants before plowing; cultivation; seeding land not in use.
Yellow; 1/4 inch; racemes.	Running rootstocks, seeds; in hay and clover seed.	Rich prairie soil; all crops.	Deep cultivation during dry weather.
Yellow; 3/4 inch; heads.	Running rootstocks; seeds carried by wind	Rich soil; all crops	Close grazing induced by salting plants; deep cultivation during dry weather; heavy seeding.
Green; 1 line; spike.	Seeds; in grain and grass seed.	Broken land, especially grainfields; all crops.	Mowing or burning stubble; use of clean seed; cultivation throughout the season.
Green; 1 line; spikes in panicles.	Seeds; in grain and grass seed; blown over snow.	Broken land; hoed crops.	Later cultivation in hoed crops; burning seed-bearing plants.
Red, purple, or white; 1/4 inch; axillary.	Seeds; in grain and grass seed.	Sandy land; poisonous.	Burning thick patches; cultivation and increased fertilization.
Green; 1 line; spike.	Perennial roots; seeds.	Meadows, neglected gardens and lawns	Hand pulling or repeated spudding in lawns; cultivation; reseeding bare spots in meadows, and pastures.

Table of two hundred

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Plantain-leafed everlasting, Indian tobacco, lamb's tail, mouse ear.	Antennaria plantaginifolia; North America; perennial.	New England to Michigan and North Carolina.	April to June	May to July..
Poison ivy, poison oak, poison vine.	Rhus radicans; eastern United States; perennial.	New England to Arizona.	May to July..	July to August.
Poison weed	Delphinium bicolor; northern United States; perennial.	Montana to Colorado.	.....do	June to September.
Pokeweed, garget, pigeon berry, skoke.	Phytolacca decandra; eastern United States; perennial.	Pennsylvania to Alabama.	July to September.	September to December.
Polanisia	Polanisia graveolens; northern United States; annual.	Iowa to Colorado.	June to August.	July to September.
Porcupine grass, needle grass.	Stipa spartea; prairie States; perennial.	Minnesota to Wyoming.	May to June	June to July.
Poverty-weed	Iva axillaris; Rocky Mountains; perennial.	Montana to New Mexico.	June to August.	July to September.
Prickly lettuce, compass weed, milkweed, wild lettuce.	*Lactuca scariola;* Europe; annual.	Ohio to Iowa, and Utah to Oregon and California.	June to October.	July to November.
Prickly pear, Indian fig.	Opuntia humifusa; southeastern United States; perennial.	Florida to Missouri.	June to August.	July to September.
Purslane, garden purslane, pursley, pusley.	*Portulaca oleracea;* Old World; annual.	In all States ...	May to November.	June to December.
Rabbit's-foot clover, stone clover.	*Trifolium arvense;* Europe; annual.	New Jersey to Michigan and southward.	May to July..	June to August.
Ragweed, bitterweed, hogweed, little ragweed, richweed, Roman wormwood.	Ambrosia artemisiæfolia; eastern United States; annual.	All States east of the Rocky Mountains.	July to September.	August to December.
Ramsted, butter and eggs, devil's flax, impudent lawyer, snapdragon, toadflax.	*Linaria linaria;* Europe; perennial.	New England to Wisconsin and southward.	July to October.	August to November.
Rattlebox	Crotalaria sagittalis; eastern United States; annual.	Iowa to South Dakota.	July to September.	.....do........
Red chess	*Bromus rubens;* southern Europe; annual.	Oregon and California.	June to July.	June to August.
Rib grass, black plantain, buck horn, buck plantain, deer tongue, English plantain, lance-leafed plantain, ripple grass.	*Plantago lanceolata;* Europe; perennial.	In all States where clover or introduced grasses are cultivated.	June to October.	July to November.
Rough-stemmed fleabane.	Erigeron ramosus; eastern United States; perennial.	Maine to Kentucky.	June to August.	July to September.
Round-leafed mallow, cheeses, mallard.	*Malva rotundifolia;* Europe; perennial.	New England to Michigan.	May to October.	June to November.
Running brier, dewberry, low blackberry.	Rubus canadensis; eastern United States; perennial.	Maryland to North Carolina.	May to July.	June to August.
Russian thistle, Russian cactus, Russian saltwort, Russian tumbleweed.	*Salsola kali tragus;* Russia; annual.	Michigan to Colorado, Idaho, and California.	July to September.	August to November.
St. Barnaby's thistle, Barnabas, prickly tarweed, yellow-flowered centaury.	*Centaurea solstitialis;* Europe; annual.	California......	May to September.	June to October.
St. John's wort..........	*Hypericum perforatum;* Europe; perennial.	New York to North Carolina.	May to August.	June to September.
Shepherd's purse, mother's heart, pickpurse, toothwort.	*Bursa bursa-pastoris;* Old World, annual.	In all States ...	January to December.	March to December.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
White; $\frac{1}{4}$ inch; heads in short spikes.	Running rootstocks; seeds blown by wind.	Hilly pastures and meadows.	Increased fertilization, cultivation, and seeding.
Yellow; $\frac{1}{4}$ inch; racemes.	Running rootstocks; seeds.	Moist, rich land, along fences; poisonous by contact.	Cultivation with hoed crops; repeated grubbing.
Yellow and purple; $\frac{3}{4}$ inch; raceme.	Perennial roots, seeds; in hay and grass seed.	Dry hills; poisonous to stock.	Cultivation and reseeding; spudding or pulling.
White; $\frac{1}{4}$ inch; racemes.	Perennial roots, seeds.	Waste land, grainfields; root poisonous.	Spudding; repeated mowing; cultivation.
......*do*..........	Seeds; in hay and grass seed.	Meadows and grainfields.	Cultivation with hoed crops; early mowing; burning grain stubble.
Green; 1 line; panicle.	Perennial roots, seeds; in hay.	Meadows and pastures; awns injurious to stock.	Mowing in May; cultivation.
Yellow; $\frac{1}{4}$ inch; heads.	Running roots, seeds.	Cultivated land; all crops.	Late cultivation with hoed crops; heavy seeding.
Yellow; $\frac{1}{4}$ inch; heads in panicles.	Seeds; carried by wind.	Everywhere; all crops.	Cultivation; heavy seeding; burning mature plants.
Yellow; 3 inches; solitary.	Perennial roots; seeds.	Sandy or sterile soil.	Burning; cultivation; fertilization; heavy seeding.
Yellow; $\frac{1}{4}$ inch; axillary.	Seeds	Cultivated land; garden crops.	Closer cultivation late in season; seeding with winter annuals after hoed crops.
Gray; $\frac{1}{8}$ inch; heads.	Seeds; in hay and clover seed.	Sandy land; meadows, and grain.	Cultivation; increased fertilization; heavy seeding.
Yellow; $\frac{1}{4}$ inch; heads in racemes; pistillate, green; axillary.	Seeds; in grain, clover seed, hay; blown over snow.	Everywhere; all crops.	Late cultivation in hoed crops, followed by seeding with winter annuals; burning or mowing wheat stubble.
Yellow; $\frac{1}{8}$ inch; racemes.	Rootstocks; seeds in grass seed.	Meadows and pastures.	Cultivation and heavy cropping.
Yellow; $\frac{1}{4}$ inch; racemes.	Seeds; pods blown over snow.	Sandy or moist land; poisonous to stock.	Cultivation with hoed crops; burning the plants in August.
Red; $\frac{1}{2}$ line; spicate panicle.	Seeds; in grass seed, hay, and wool.	Sandy land, sheep pastures; awns injure sheep.	Cultivation; burning the grass as soon as the panicles form.
White; $\frac{1}{16}$ inch; spike.	Perennial root; seeds; in hay, clover, and grass seed.	Everywhere; all crops.	Cultivation and heavy cropping; repeated spudding in lawns.
White; $\frac{1}{2}$ inch; heads.	Perennial roots; seeds; in hay and grass seed.	Meadows and pastures.	Cultivation; pulling from meadows while in blossom.
White; $\frac{1}{4}$ inch; axillary.	Running rootstocks; seeds.	Cultivated land; grain and neglected gardens.	Thorough cultivation with hoed crops; persistent spudding in lawns.
White; 1 inch; solitary.	Perennial roots......	Old fields; all crops..	Alternate cultivation and heavy cropping; increased fertilization.
Purplish; $\frac{1}{4}$ inch; axillary.	Seeds; blown as a tumbleweed.	Broken land; small grain.	Cultivation until August in hoed crops; burning wheat stubble; harrowing fire breaks.
Yellow; 1 inch; heads.	Seeds; carried by wind and by animals.	Cultivated land; all crops.	Cultivation with hoed crops; burning patches of mature plants.
Yellow; $\frac{1}{4}$ inch; cymes.	Running rootstocks; seeds; in hay, clover and grass seed.	Meadows, pastures, and neglected hoed crops.	Thorough cultivation with hoed crops; cutting or pulling in meadows before mowing.
White; $\frac{1}{16}$ inch; racemes.	Seeds	Everywhere; all crops.	Thorough cultivation in hoed crops, followed by seeding with winter annuals.

Table of two hundred

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Showy spurge, flowering spurge.	Euphorbia corollata; eastern United States; perennial.	New York to Wisconsin and Missouri.	June to September.	July to November.
Silvery cinquefoil	Potentilla argentea; northern United States; perennial.	Ohio to Michigan.	May to September.	June to October.
Skeleton weed, gum weed, lygodesmia.	Lygodesmia juncea; northern plains; perennial.	South Dakota to Colorado.	June to August.	July to September.
Skunkweed, pepper weed.	Navarretia squarrosa; Pacific Coast; annual.	Washington to California and Nevada.	May to July	June to September.
Slender nettle	Urtica gracilis; northern United States; perennial.	New England to Minnesota.	June to September.	July to November.
Small carrot, bristly carrot, Southern carrot.	Daucus pusillus; southern United States; biennial.	Florida to Arizona.	April to May.	May to June.
Small cocklebur, ditch bur, small burdock.	*Xanthium strumarium;* Old World; annual.	Florida to California.	June to September.	July to November.
Small-flowered geranium.	*Geranium pusillum;* Europe; annual.	Michigan to Illinois.	May to July	June to August.
Small-flowered mallow, malva.	*Malva parviflora,* Europe; annual.	California	June to September.	July to November.
Sneeze weed	Helenium autumnale; eastern United States; perennial.	Maryland to Iowa and southward to the Gulf States.	July to September.	August to October.
Sorrel, field sorrel, horse sorrel, red sorrel, sheep sorrel, sour weed.	*Rumex acetosella;* Europe; perennial.	New England to Wisconsin and southward; Washington and Oregon.	May to October.	June to November.
Sow thistle, milk thistle.	*Sonchus oleraceus;* Europe; annual.	Pennsylvania to Wisconsin.	June to August.	June to September.
Spanish bur	*Urena lobata;* South America; perennial.	Alabama to Florida.	May to July	do
Spiny amaranth, prickly calula, red careless weed, spiny careless weed, thorny amaranth.	*Amaranthus spinosus;* tropical America; annual.	Virginia to Missouri and southward.	July to November.	August to December.
Spiny cocklebur, Bathurst bur, Chinese thistle, dagger cocklebur.	*Xanthium spinosum;* Tropics; annual.	Maryland to Texas and California.	July to October.	do
Spiny nightshade	*Solanum aculeatissimum;* Tropics; annual.	Texas to Florida.	June to September.	July to October.
Spiny sida	*Sida spinosa;* Tropics; annual.	Florida to Texas and Kansas.	June to August.	July to September.
Spotted cowbane, beaver poison, musquash poison, water hemlock.	Cicuta maculata; northern United States; perennial.	Throughout the United States.	July to August.	August to September.
Squirrel tail, foxtail, wild barley.	Hordeum jubatum; western United States; annual.	California to Texas and Minnesota.	May to July	June to August.
Star thistle	*Centaurea calcitrapa;* southern Europe; annual or biennial.	New Jersey to Georgia.	July to October.	September to December.
Steel weed, aster	Aster ericoides; eastern United States; perennial.	Maryland to Ohio and southward.	August to November.	do
Stick-seed, beggar's lice	Lappula virginiana; eastern United States; biennial.	New England to Minnesota and Louisiana.	June to July.	July to August.
Stinking grass, pungent meadow grass.	*Eragrostis major;* Old World; annual.	New Jersey to Michigan and south to the Gulf States.	July to September.	July to October.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
White; $\frac{1}{4}$ inch; umbel.	Running roots; seeds; in hay and grass seed.	Rich or sandy soil; pastures, meadows, grain.	Thorough cultivation until midsummer; mowing in July, followed by deep plowing in August.
Yellow; $\frac{1}{4}$ inch; axillary.	Perennial roots; seeds.	Sandy land; meadows and pastures.	Deep cultivation in dry weather; increased fertilization.
Pink; $\frac{1}{4}$ inch; heads.	*Perennial roots*; seeds; carried by wind.	Pastures and meadows.	Cultivation; mowing or grubbing as often as flowers appear.
Blue; $\frac{1}{4}$ inch; axillary.	Seeds	Broken land; hay and grain injured by its odor.	Cultivation with hoed crops; repeated cutting; burning mature plants.
Green; 1 line; clustered in panicled spikes.	Running rootstocks; seeds.	Moist land; marsh pastures and muckland crops; stinging when touched.	Mowing in June and again in August; burning mature plants.
White; $\frac{1}{16}$ inch; umbels.	Seeds; carried by wind and animals.	Everywhere; all crops.	Cultivation in autumn or early spring; seeding with winter annuals.
Green; 1 line; heads in racemes or axillary.	Seeds; burs carried by animals.	Broken land; all crops, wool.	Cultivation with hoed crops; burning mature plants.
Pink; $\frac{1}{4}$ inch; axillary.	Seeds; in clover and grass seed.	Sandy land; meadows, pastures, and lawns.	Cultivation and increased fertilization.
Purple; $\frac{1}{2}$ inch; solitary.	Seeds	Clay soil; all crops	Late cultivation with hoed crops; heavy seeding on land not in use.
Yellow; $\frac{1}{4}$ inch; heads.	Rootstocks; seeds	Meadows and pastures; injurious to stock.	Cultivation with hoed crops; pulling or repeated spudding in pastures and meadows.
Red; $\frac{1}{8}$ inch; panicle.	Running rootstocks, seeds; in clover seed.	Meadows, pastures, and grainfields.	Cultivation; increased fertilization; reseeding worn-out pastures.
Yellow; $\frac{1}{2}$ inch; heads.	Seeds; carried by wind.	Meadows and grainfields.	Cutting or pulling when the first blossoms appear; burning mature plants.
Rose; $\frac{1}{4}$ inch; racemes.	Seeds; carried by animals.	Sandy land; wool	*Cultivation; cutting and burning* mature plants.
Green; $\frac{1}{16}$ inch; spikes.	Seeds; in clover seed.	Pastures, meadows, and grainfields.	Cultivation with hoed crops.
Green; $\frac{1}{5}$ inch; heads.	Seeds; burs carried by animals.	Pastures and meadows; wool.	Thorough cultivation with hoed crops during two or three successive seasons; burning mature plants.
White; 1 inch; raceme.	Seeds	Pastures and hoed crops.	Thorough cultivation; burning mature plants.
Yellow; $\frac{1}{4}$ inch; axillary.	do	Meadows, pastures, and grainfields.	Cultivation with hoed crops; cutting plants when they begin to blossom.
White; 1 line; umbels.	Perennial roots; seeds.	Moist pastures and meadows; poisonous when eaten.	Repeated spudding or grubbing.
Green; $\frac{1}{2}$ line; spikes.	Seeds; hay, animals, and wind.	Meadows and pastures; awns injurious to animals.	Cultivation; early mowing; burning patches of the grass.
Purple; $\frac{1}{2}$ inch; heads.	Seeds	Meadows and pastures.	Cultivation; seeding with winter annuals.
White; $\frac{1}{8}$ inch; heads.	Rootstocks; seeds; carried by wind.	Old fields, meadows, and pastures.	Late cultivation with hoed crops; increased fertilization.
Blue; 1 line; racemes.	Seeds; carried by animals.	Along fences, in pastures; wool.	Cultivation with hoed crops; spudding or pulling.
Green; 1 line; spikes in panicles.	Seeds in grass and clover seed.	Sandy land; hay and all crops.	Thorough cultivation with hoed crops.

Table of two hundred

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Stramonium, jimson weed, thorn apple.	*Datura stramonium;* Old World; annual.	New Jersey to Texas.	July to October.	September to December.
Stubble spurge, hypericum spurge.	Euphorbia nutans; eastern United States; annual.	Maryland to Missouri.	....do	August to November.
Sunflower	Helianthus annuus; central United States; annual.	Nebraska to Louisiana and Texas.	July to September.	August to October.
Swamp beggar ticks, marigold.	Bidens connata; eastern United States; annual.	New England to Minnesota and southward.	....do	August to November.
Sweet clover, bokhara clover, white melilot.	*Melilotus alba;* Old World; perennial.	Maryland to Michigan.	June to August.	July to September.
Tall buttercup, acrid buttercup.	*Ranunculus acris;* Europe; perennial.	New England to New York.	May to July..	June to August.
Tall thistle	Carduus altissimus; northern United States; perennial.	Wisconsin to Missouri.	July to September.	August to September.
Tarweed, California tarweed.	Madia sativa; Pacific Coast; annual.	Washington to California.	May to October.	June to November.
Teasel, barber's brushes, English thistle, Fuller's card, Indian thistle, water thistle.	*Dipsacus sylvestris;* Europe; biennial.	Ohio to Tennessee and California.	July to September.	August to October.
Texas thistle, American centaury, star thistle.	Centaurea americana; southern United States; annual.	Texas to Kansas.	May to July..	June to August.
Three-seeded mercury, copper leaf.	Acalypha virginica; eastern United States; annual.	Pennsylvania to Texas.	July to September.	August to November.
Tumbleweed, white pigweed.	Amaranthus albus; central United States; annual.	Illinois to Kansas.	August to September.	August to October.
Velvety gaura, small-flowered gaura.	Gaura parviflora; southern prairie States; annual.	Kansas to Texas.	July to September.	....do ......
Venus looking-glass.....	Legouzia perfoliata; eastern United States; annual.	Michigan to Georgia.	May to July .	June to August.
Viper's bugloss, blue devil, blue thistle, blue weed.	*Echium vulgare;* Europe; biennial;	New York to North Carolina.	May to October.	June to November.
Water hyacinth, gamalote.	*Eichhornia crassipes;* South America; perennial.	Florida and Louisiana.	July to September.	....
Water smartweed......	Polygonum emersum; eastern United States; perennial.	New York to South Dakota.	July to October.	August to November.
West India bur grass, cockspur, sandspur.	*Cenchrus echinatus;* Tropics; annual.	Florida to Texas.	May to September.	June to November.
White mustard........	*Sinapis alba;* Europe; annual.	New England to Ohio.	May to August.	June to September.
Whitetop, June grass, old fog, wild-cat grass.	Danthonia spicata; eastern United States; annual.	Vermont to Tennessee.	May to July..	June to July.
White vervain, nettle-leafed vervain.	Verbena urticifolia; eastern United States; perennial.	New Jersey to Wisconsin.	June to August.	July to September.
Wild buckwheat, black bindweed.	*Polygonum convolvulus;* Europe; annual.	Ohio to North Dakota.	....do	....do ......
Wild carrot, bird's nest, devil's plague, Queen Anne's lace.	*Daucus carota;* Old World; biennial.	New England to Ohio and southward to Georgia.	July to September.	August to December.
Wild gourd, calabazita..	Cucurbita perennis; southwestern United States; perennial.	California to New Mexico.	April to July.	July to November.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
White; 2 inches; solitary.	Seeds	Waste land and neglected gardens; poisonous.	Mowing or spudding in July.
White; ⅛ inch; cymes.	do	Meadows and grain-fields.	Mowing stubble; cultivation.
Yellow; 2 inches; heads.	do	Broken land; all crops.	Thorough cultivation; mowing or burning sunflowers along rivers.
Yellow; ⅛ inch; heads.	Seeds; carried by animals.	Moist land; pastures, wool.	Cultivation; mowing.
White; 1 line; racemes.	Perennial roots, seeds; in hay and clover seed.	Clay soil; meadows and hoed crops.	Plowing in July and August.
Yellow; ¼ inch; solitary.	Rootstocks, seeds; in hay.	Moist land; pastures and meadows.	Early mowing; repeated spudding; cultivation.
Purple; 1½ inches; heads.	Perennial roots, seeds; carried by winds.	Meadows and pastures.	Repeated spudding or mowing as often as heads form.
Yellow; 1 inch; heads.	Seeds	Everywhere; viscid excretion injures everything coming in contact with it.	Cultivation.
White; 1 inch; head.	do	Meadows and pastures.	Cultivation with hoed crops; burning mature plants; mowing as often as heads are formed.
Purple; 2 inches; heads.	Seeds; carried by winds.	Cultivated land; all crops.	Thorough cultivation.
Green; ½ line; axillary clusters.	Seeds	Moist land; grain and hay.	Thorough cultivation until midsummer with hoed crops.
Green; ½ line; spikes.	Seeds; weed blown as a tumbleweed.	Broken prairie land; all crops.	Late cultivation in hoed crops.
Rose; ¼ inch; spikes.	Seeds	Meadows and grain, fields.	Cultivation with hoed crops; pulling or mowing plants when first blossoms appear.
Blue; ¼ inch; spikes.	Seeds; in clover seed.	Grainfields and thinly seeded meadows.	Thorough cultivation and increased fertilization.
Blue; ¼ inch; thyrsus.	Seeds	Meadows and pastures.	Cultivation; thick seeding; spudding in permanent pastures.
Purple; ½ inch; racemes.	Offshoots; floating in currents and blown by wind.	Slow-running water; obstructs draining and navigation.	Fishing plants out; prevention of spreading from gardens.
Pink; 1 line; spikes.	Running rootstocks; seeds.	Moist land; lowland pastures, meadows, and muck-land crops.	Thorough cultivation in dry weather, and heavy seeding with lowland grasses.
Green; 1 line; in burs.	Seeds; burs carried by animals.	Orange groves and broken land; wool.	Thorough cultivation.
Yellow; ¼ inch; racemes.	Seeds	Meadows and grain-fields.	Cultivation with hoed crops; hand pulling.
Gray; 1 line; spikelets in panicles.	Seeds; in grass seed.	Dry, hilly pastures and meadows.	Increased fertilization; cultivation; early mowing.
White; 1 line; spikes.	Running rootstocks; seeds.	Moist meadows, pastures, and muck-land crops.	Repeated mowing; cultivation.
White; 1 line; racemes.	Seeds; in grain seed.	Grain and corn fields; injures grain and obstructs harvesting machinery.	Thorough cultivation with low-growing hoed crops.
White; 1 line; umbels.	Seeds; carried by animals and wind.	Meadows and pastures.	Cultivation; increased fertilization; hand pulling; repeated mowing while in blossom.
Yellow; 3 inches; solitary.	Perennial roots; seeds.	Cultivated lands	Killing the roots with coal oil or strong brine.

Table of two hundred

Common names.	Technical name, origin, and duration.	Where injurious.	Time of flowering.	Time of seeding.
Wild licorice	Glycyrrhiza lepidota; northwestern U. S.; perennial.	Minnesota to California.	June to August.	August to November.
Wild oats	*Avena fatua;* Old World; annual.	Wisconsin to Utah.	July to August.	July to August.
Wild onion, crow garlic, field garlic, wild garlic.	*Allium vineale;* Europe; perennial.	Pennsylvania to South Carolina.	June to July.	....do
Wild parsnip, queen weed	*Pastinaca sativa;* Old World; biennial.	New England to Ohio.	June to September.	July to October.
Winged pigweed, cycloloma, sand-hill tumble weed.	Cycloloma atriplicifolia; prairie States; annual.	Nebraska to Texas.	July to September.	August to December.
Yard grass, dog's tail, crab grass, wire grass.	*Eleusine indica;* Tropics; annual.	New Jersey to Texas.	July to October.	August to November.
Yellow bur weed, fireweed, yellow tarweed.	*Amsinckia intermedia;* Pacific Coast; annual.	California	May to July	June to August.
Yellow daisy, brown-eyed Susan, cone flower, niggerhead, ox-eye daisy.	Rudbeckia hirta; central United States; biennial.	New England to Ohio.	June to August.	July to September.
Yellow dog fennel, fennel.	Helenium tenuifolium; southern U. S; annual.	Georgia to Texas.	July to October.	August to November.
Yellow melilot, yellow sweet clover.	*Melilotus officinalis;* Europe; annual.	Maryland to Michigan.	June to September.	July to October.
Yerba mansa	Anemopsis californica; southwestern U. S.; perennial.	California and Arizona.	May to September.	June to October.

IRRIGATION.

A water right is the right or privilege of using water for irrigating purposes, either in a definite quantity or upon a prescribed area of land, such right or privilege being customarily acquired either by priority of use or by purchase. In many parts of the arid region a water right is an exceedingly valuable property. The average value of the water rights of the entire arid region, as determined by the census of 1890, was $26 per acre, and there are fruit-growing districts in California where water rights have been sold at as high as $1,500 per miner's inch, or from $100 to $500 per acre, according to the amount used on any given area of land.

The duty of water is the extent of the service it will perform when used for irrigating purposes; that is, the number of acres a given quantity of water will adequately irrigate under ordinary circumstances. This is usually from 100 to 200 acres for each second-foot. Where water is abundant, the duty has been known to be as low as 50 acres, and, where very scarce, as high as 500 acres to the second-foot.

A miner's inch is theoretically such a quantity of water as will flow through an aperture 1 inch square in a board 2 inches thick under a head of water of 6 inches in one second of time, and it is equal to 0.194 gallon, or 0.0259337 cubic foot per second, or to 11.64 gallons, or 1.556024 cubic feet, per minute. The amount of water flowing through a given aperture in a given times varies, however, with the head of water over the opening and also with the form of the opening. In Colorado the miner's inch legalized by statute equals 11.7 gallons per minute. The California miner's inch, however, equals only 9 gallons per minute, 100 Colorado inches being, accordingly, equal to 130 California inches. One hundred Colorado inches will cover an acre to a depth of 5.2 feet in twenty-four hours; 100 California inches will cover the same area only to a depth of 4 feet in the same time. Fifty California inches are, therefore, approximately equal to 1 second-foot, and 50 Colorado inches to about three-tenths more.

An acre-foot of water is the amount required to cover an acre of ground to a depth of 1 foot. This is 43,560 cubic feet, or 325,851.4512 gallons. Its weight is 1,213 tons 2,113 pounds, at 2,240 pounds to the ton.

The amount of water required to cover an acre of ground to a depth of 1 inch is 3,630 cubic feet, or 27,154.2876 gallons. Its weight is 101 tons 362¾ pounds, at 2,240 pounds to the ton.

weeds—Continued.

Color, size, and arrangement of flowers.	Method of propagation and distribution.	Place of growth and products injured.	Methods of eradication.
Bluish white; ⅛ inch; racemes.	Running rootstocks, seeds; *burs carried* by animals.	Open prairie; burs very *injurious* in wool.	Subsoiling in dry weather; *persistent cultivation during three* successive seasons.
Green; 1 line; panicle.	Seeds; in seed oats..	Oat fields; awns injurious to stock.	Pulling and burning before harvesting oats; cultivation with hoed crops.
White; 1 line; umbel.	Bulbs, offsets, bulblets; bulblets carried like seeds in grain.	Everywhere; dairy products, grain.	Alternate cultivation and heavy cropping; application of carbolic acid.
Yellow; 1 line; umbel.	Seeds	Meadows, pastures..	Cultivation with hoed crops; frequent mowing.
Green; ¼ inch; axillary.	Seeds; *carried* by wind as a tumbleweed.	Broken *land; grain* and hoed crops.	*Thorough cultivation until* midsummer in hoed crops; burning mature plants.
Green; ½ line; spikes.	Seeds; in grass seed.	Lawns, pastures, and meadows.	Spudding or hand pulling in lawns; cultivation; increased fertilization.
Yellow; ¼ inch; racemes.	Seeds; carried by animals.	Grainfields and vineyards.	Cultivation with hoed crops.
Yellow and brown; 1 inch; head.	Seeds; in hay........	Meadows and pastures.	Cultivation with hoed crops; hand pulling; repeated mowing.
Yellow; ½ inch; head.	.....do	Meadows, pastures, and grainfields.	Cultivation, increased fertilization.
Yellow; 1 line; racemes.	Seeds; in hay and clover seed.	Clay soil; dry meadows and pastures.	Cultivation, increased fertilization; reseeding meadows.
White; ¼ inch; spike.	Rootstocks, seeds...	Moist land, cultivated crops.	Alternate cultivation and heavy cropping; drainage.

A second-foot is the most satisfactory, because the most definite, unit of measurement for flowing water. It is used by the United States Government in the gauging of rivers and streams, and is rapidly superseding the miner's inch in the measurement of water for irrigation. It is the quantity represented by a stream 1 foot wide and 1 foot deep, flowing at the average rate of 1 foot per second. In other words, it is 1 cubic foot per second, 60 cubic feet per minute, 3,600 cubic feet per hour, and so on. A stream flowing continuously at the average rate of 1 second-foot would carry in one day of twenty-four hours 86,400 cubic feet, or 646,316.928 gallons, sufficient to cover $1\frac{119}{121}$ acres to a depth of 1 foot. Flowing continuously for one year of three hundred and sixty-five days, such a stream would carry 31,536,000 cubic feet, or 235,905,678.72 gallons, sufficient to cover $723\frac{117}{121}$ acres to a depth of 1 foot.

The subhumid region is the strip of country running north and south between the arid region, where irrigation is absolutely necessary to the successful prosecution of agriculture, and those portions of the United States in which the rainfall is usually sufficient for agricultural purposes. It includes portions of North Dakota, South Dakota, Nebraska, Kansas, and Texas, and may be described as a region where irrigation is not always necessary, but where agricultural operations can not, with any assurance of success, be undertaken without it.

The average value of the irrigated land in farms in the United States was ascertained by the census of 1890 to be $83.28 per acre, and that of the nonirrigated land in farms $20.95 per acre.

The average annual value of the agricultural products of the irrigated land was ascertained to be $14.89 per acre irrigated, and that of those of the nonirrigated land $6.80 for each acre improved.

The average first cost of the irrigated land, including purchase money, water rights, etc., was ascertained to have been $8.15 per acre, and the average annual cost of the water supply $1.07 per acre.

The total value of the irrigated farms of the United States, as reported by the farmers themselves, was, in round figures, $296,850,000, an increase of $219,360,000, or 283.08 per cent, upon their cost, including land, water rights, fences, and preparation for cultivation.

The total value of the productive irrigating systems was found to be $94,412,000, an increase of $64,801,000, or 218.84 per cent, upon their cost.

NUMBER, WEIGHT, COST OF SEEDS, AND AMOUNT TO SOW PER ACRE.

ıble giving the number of grains in 1 pound of seed of the principal grasses and forage plants, the amount to sow per acre of seed of standard purity, the amount to sow of pure and germinating seed, the weight per bushel, the cost of seed per acre, and the weight of 10,000,000 seeds, which is the standard amount per acre in composing mixtures.

[Columns 1, 2, 3, and 4 are compiled from The Best Forage Plants, by Stebler & Schroeter. The figures in column 5 are obtained by multiplying the amount of ındard quality of seed required (column 2) by the retail price per pound quoted in New York catalogues. The weight of 10,000,000 grains (column 6) is obtained · dividing this quantity by the number of seeds in 1 pound (column 1).]

Name.	(1) Number of grains in 1 pound of pure seed.	(2) Amount to sow per acre, in pounds, standard quality.	(3) Amount to sow per acre, in pounds, of pure germinating seed.	(4) Weight per bushel.	(5) Cost of seed per acre	(6) Weight of 10,000,000 grains.	Remarks.
				Pounds.		*Pounds.*	
edtop (*Agrostis alba*)......	603,000	9.7	7.00	8–32	$1.45	16.58	Requires moist climate or damp soil. Best propagated by transplanting small turf cuttings in autumn. Valuable for late pasturage or lawns in the New England and Middle States. Use 5 to 10 per cent in mixtures.
eed canary grass (*Phalaris arundinacea*).	660,000	21.0	12.00	44–48	7.35	15.15	Adapted to stiff, wet lands and flooded fields. Requires moisture. Valuable hay when cut young, and well suited for binding loose banks near running water or for forming a firm sod on marshy ground.
nooth-stalked meadow grass (*Poa pratensis*).	2,400,000	17.5	8.40	....	2.10	4.17	Grows best on soils which are strongly calcareous. Well adapted for pasture, and makes a good bottom grass for meadows. An excellent lawn grass.
ough-stalked meadow grass (*Poa trivialis*).	3,000,000	19.5	8.75	11–17	4.88	3.33	Should be sown only on moist, fertile, and sheltered soils in mixtures.
ıeep's fescue (*Festuca ovina*).	680,000	28.0	12.60	10–15	4.20	14.85	Light, dry soils, especially those which are poor, shallow, and silicious. Valuable bottom grass and for sheep pastures. Sown only in mixtures.
arious-leafed fescue (*Festuca heterophylla*).	400,000	33.5	19.50	....	8.38	25.00	Best on moist, low lands containing humus, and sandy loams. Withstands drought; useful in pasture; unimportant for hay. Alone it makes no continuous turf.
reeping fescue (*Festuca rubra*).	600,000	42.5	13.00	10–15	8.50	16.66	Valuable pasture or bottom grass Withstands drought; endures both cold and shade. On poor land, especially moist sands and railway banks, serves to bind the soil. Product small.
wnless brome grass (*Bromus inermis*).	137,000	44.0	35.60	....	8.80	72.99	Valuable for light soils, especially in regions subject to extremes of heat or long periods of drought. Used alone or in mixtures for permanent meadows and pastures.
erennial rye grass (*Lolium perenne*).	336,800	55.0	38.50	18–30	4.95	29.70	Excellent and lasting pasture grass for heavy soils in moist, cool climates. On light, dry soils disappears after the second year. Rarely sown alone.

Italian rye grass (*Lolium italicum*).	285,000	48.5	32.40	12-24	3.56	35.10	Excellent for rich and rather moist lands. **Regarded in Europe as one of the best for hay. Lasts only 2 or 3 years.**
Orchard grass (*Dactylis glomerata*).	579,500	35.0	....	12-16	5.60	17.25	Grows well on any soil, excepting that which is very wet; withstands shade. Affords a great amount of aftermath. Valuable alike for hay and pasturage.
Meadow fescue (*Festuca pratensis*).	318,200	52.0	....	12-26	7.80	31.42	Thrives in either dry or wet soils. Valuable hay or pasture grass.
Meadow oat grass (*Arrhenatherum avenaceum*).	159,000	70.0	34.30	10	12.60	62.89	Thrives on moist, loamy sands, or light clays which are not too moist, and marls. Spring most favorable seed time. Valuable in the South for hay or winter pasture.
Yellow oat grass (*Trisetum flavescens*).	2,045,000	29.0	4.64	5¼	24.65	4.89	Valuable for temporary or permanent pastures. Thrives on marly or calcareous soil, in all light land rich in humus.
Velvet grass (*Holcus lanatus*).	1,304,000	22.0	8.80	6¼	4.40	7.66	Sometimes sown on light, thin soils, unsuited for more valuable sorts. Rarely used excepting in mixtures.
Timothy (*Phleum pratense*).	1,170,500	16.0	14.00	48	1.50	8.54	Best known and most extensively cultivated for hay, sown alone or mixed with redtop or clover. Succeeds best on moist loams or clays. On dry ground the yield is light.
Meadow foxtail (*Alopecurus pratensis*).	907,000	23.0	6.21	6	6.21	11.02	Endures cold. Likes strong soil, stiff loam or clay. One of the best for land under irrigation. Very early. Two to four pounds in mixtures for permanent pastures.
Vernal grass (*Anthoxanthum odoratum*).	924,000	30.0	7.80	....	15.00	10.82	Grows on almost any kind of soil; sown only in mixtures, 1 to 2 pounds with permanent pasture or meadow grasses.
Crested dog's tail (*Cynosurus cristatus*).	1,127,000	25.0	13.50	20-32	7.50	8.87	Especially adapted for loams, light clays, marls, and moist, loamy sands. Moist climates are most suitable; withstands drought and thrives well in shade. Nutritive value high. Used in mixtures to form bottom grass either in pasture or hay.
Alsike clover (*Trifolium hybridum*).	707,000	12.3	9.00	94-100	1.60	14.14	Grows on strongest clay or peaty soil; peculiarly adapted to damp ground. Bears heavy frosts without injury. Sow in August or February.
Sainfoin (*Onobrychis sativa*).	22,500	[1] 78.0	[1] 60.84	40	6.25	444.44	Requires good and open subsoil, free from water. Sown alone, from end of March to beginning of May.
Red clover (*Trifolium pratense*).	279,000	18.0	15.84	64	2.50	35.84	Succeeds best in rich, loamy soil, on good clays, and on soils of an alluvial nature. A standard fodder plant.
White clover (*Trifolium repens*).	740,000	10.5	7.50	63	2.94	13.51	Thrives on mellow land containing lime, and on all soils rich in humus. Resists drought. Generally used in mixtures for pastures or lawns.
Common kidney vetch (*Anthyllis vulneraria*).	154,000	17.5	15.00	60-64	4.58	67.15	Cultivated for grazing; on warm soils, if manured and of proper depth. Hardy; resists drought. Sheep, goats, and horned cattle eat it greedily.
Alfalfa, or lucern (*Medicago sativa*).	209,500	25.0	22.00	61-63	3.25	48.56	Grows well on any calcareous soil having a permeable subsoil. Especially adapted to the warm and dry regions of the West and Southwest. Requires irrigation.
Trefoil (*Medicago lupulina*).	328,000	18.0	14.75	64-66	2.16	30.48	Any soil containing sufficient moisture and lime is suitable. Most successful on clay marls. Cultivated only where the better kinds of clover can not be grown.
Bird's-foot trefoil (*Lotus corniculatus*).	375,000	11.0	4.67	60	4.40	26.66	Thrives on dry or moist, sandy or clayey soils. Well suited to dry lands at high elevations, though poor.
Officinal goats' rue (*Galega officinalis*).	62,000	22.0	6.90	....	4.14	161.29	Excellent fodder plant for warm, sheltered situations. Thrives only in deep soil, and when subsoil is not wet.

[1] Unshelled.

Table showing weight and cost of the seed of four mixtures, each designed to cover an acre, upon the basis of 10,000,000 plants, compiled from Table 1.

		Number of seeds.	Pounds.	Cost
A.	Timothy	6,700,000	5.72	$0.57
	Alsike	1,650,000	2.33	.30
	White clover	1,650,000	2.23	.62
	Total	10,000,000	10.28	1.49
B.	Timothy	5,000,000	4.27	.43
	Kentucky blue grass	1,000,000	.41	.05
	Orchard grass	700,000	1.21	.19
	Alsike	1,650,000	2.33	.30
	White clover	1,650,000	2.23	.62
	Total	10,000,000	10.45	1.59
C.	Timothy	4,000,000	3.42	.34
	Kentucky blue grass	1,200,000	.50	.06
	Orchard grass	1,000,000	1.73	.28
	Meadow foxtail	500,000	.55	.15
	Alsike	1,650,000	2.33	.30
	White clover	1,650,000	2.23	.62
	Total	10,000,000	10.76	1.75
D.	Red clover	2,790,000	10	1.40
	Alsike	2,121,000	3	.39
	Timothy	3,089,000	2.64	.26
	Redtop	2,000,000	3.31	.40
	Total	10,000,000	18.95	2.45

THE METRIC SYSTEM.

The entire metric system of weights and measures is based upon a fundamental unit called a meter, which is the ten-millionth part of the distance from the equator to the pole, and is the principal unit of linear measure.

The are, or unit of square measure, is a square whose side is 10 meters.

The stere, or unit of cubic measure, is a cube whose edge is a meter.

The liter, or unit of all measures of capacity, is a cube whose edge is the tenth of a meter.

The gram, or unit of weight, is the weight of a cube of pure water at its greatest density, the edge of which is the hundredth part of a meter.

Elements of the system.

Length.	Surface.	Capacity.	Weight.	Notation.
			Metric ton.	1,000,000
			Quintal.	100,000
Myriameter.			Myriagram.	10,000
Kilometer.		Kiloliter.	Kilogram.	1,000
Hectometer.	Hectare.	Hectoliter.	Hectogram.	100
Decameter.	Decare.	Decaliter.	Decagram.	10
Meter.	*Are.*	*Liter.*	*Gram.*	1
Decimeter.		Deciliter.	Decigram.	0.1
Centimeter.	Centiare.	Centiliter.	Centigram.	0.01
Millimeter.		Milliliter.	Milligram.	0.001

The metric system has been made compulsory in France, Germany, Austria-Hungary, Belgium, Spain, Portugal, Italy, Norway, Sweden, Switzerland, Servia, Roumania, Mexico, Brazil, Peru, Venezuela, and Argentina. In Great Britain, Japan, and the United States the system is legalized, but its use is not compulsory. Russia and Denmark stand alone in not having taken any action, but even these countries are contributors to the International Bureau of Weights and Measures.

In all the different countries in which this system has been adopted the change from the systems previously in use was made without the slightest difficulty, but it is hardly necessary to point out that unless the metric system had been distin-

guished by great simplicity it would not have commended itself to so large a number of the nations of the world, with all their various peculiarities and prejudices. Its superior character, both as regards simplicity and scientific precision, was recognized in the United States at an early day, and as long ago as 1866 Congress legalized the system in this country and authorized the Secretary of the Treasury to distribute to each State of the Union a set of metric standards of weights and measures, which was done. It has since authorized on different occasions the participation of the United States Government in the various operations that have been advocated by the International Bureau of Weights and Measures.

Our present system has for its sole recommendation that it has been in common use for many years. It is irrational in theory and irksome in practice, and is almost entirely without authorization in the history of Congressional legislation.

Linear, or long, measure.

	Meters.	Inches.	Feet.	Yards.	Miles.
Millimeter	0.001	0.03937	0.00328	0.00109	
Centimeter	.01	.3937	.03280	.01093	
Decimeter	.1	3.937	.32808	.10936	0.00006
Meter	1	[1] 39.37	3.28083	1.093611	.00062
Decameter	10		32.80833	10.93611	.00621
Hectometer	100		328.0833	109.3611	.06213
Kilometer	1,000		3,280.833	1,093.611	.62137
Myriameter	10,000				6.2137

[1] 39.37 inches is the legalized equivalent of the meter in the United States. The exact equivalent is 39.37079 inches.

Square measure.

	Square meters.	Square inches.	Square feet.	Square yards.	Acres.
Milliare	0.1	155	1.0764	0.1196	
Centiare, or square meter	1	1,550	10.764	1.196	
Deciare	10		107.64	11.96	0.0024
Are, or square decameter	100		1,076.4	119.6	.0247
Decare	1,000			1,196	.2471
Hectare	10,000				2.471

A square centimeter equals 0.155 square inches, a square decimeter 15.5 square inches, and a square kilometer 0.386 square miles.

Cubic measure.

	Cubic meters.	Cubic inches.	Cubic feet.	Cubic yards.
Millistere, or cubic decimeter	0.001	61.023	0.035314	
Centistere	.01	610.23	.35314	0.01308
Decistere	.1		3.5314	.1308
Stere, or cubic meter	1		35.314	1.308
Decastere	10		353.14	13.08
Hectostere	100			130.8

Measure of capacity.

	Liters.	Fluid ounces.	Quarts.	Gallons.	Bushels.
Milliliter, or cubic centimeter	0.001	0.0338	0.00106		
Centiliter	.01	.338	.01057	0.00264	
Deciliter	.1	3.38	.10567	.02642	0.002838
Liter, or cubic decimeter	1	33.8	1.0567	.26417	.028377
Decaliter	10	338	10.567	2.6417	.283774
Hectoliter	100		105.67	26.417	2.83774
Kiloliter	1,000			264.17	28.3774
Myrialiter	10,000			2,641.7	283.774

A liter is the weight of a kilogram of water at its maximum density.

Weight.

	Grams.	Grains.	Ounces avoirdupois.	Pounds avoirdupois.	Tons of 2,240 pounds.
Milligram	0.001	0.01543			
Centigram	.01	.15432			
Decigram	.1	1.54324	0.0035		
Gram	1	15.43236	.0353	0.0022	
Decagram	10	154.32356	.3527	.0220	
Hectogram	100	1,543.23564	3.5274	.22046	
Kilogram	1,000	15,432.35639	35.274	2.20462	0.000984
Myriagram	10,000			22.0462	.009842
Quintal	100,000			220.462	.09842
Millier, or tonne	1,000,000			2,204.62	9842

NOTES REGARDING DEPARTMENT PUBLICATIONS.

The publications of the U. S. Department of Agriculture are of three classes: (1) Serial publications, (2) scientific and technical reports, and (3) popular bulletins. The first two classes are issued in limited editions and are distributed free only to persons cooperating with or rendering the Department some service. Sample copies will be sent if requested, but miscellaneous applicants to receive the same regularly or for occasional copies must apply to the Superintendent of Documents, Union Building, Washington, D. C., to whom all publications not needed for official use, except circulars and bulletins printed by law for free distribution, are turned over in accordance with the following provision of the act providing for the public printing and binding and distribution of public documents, viz:

"SEC. 67. All documents at present remaining in charge of the several Executive Departments, bureaus, and offices of the Government not required for official use shall be delivered to the Superintendent of Documents, and hereafter all public documents accumulating in said Departments, bureaus, and offices not needed for official use shall be annually turned over to the Superintendent of Documents for distribution or sale."

The popular circulars and bulletins treat in a practical way of subjects of particular interest to farmers, are issued in large editions, and are for free distribution. Under this class are included the Farmers' Bulletins, of which the following are available, and for which applications should be addressed to the Secretary of Agriculture, Washington, D. C., stating both the number and title of the publication desired:

No. 3. The Culture of the Sugar Beet; No. 6. Tobacco: Instructions for its Cultivation and Curing; No. 11. The Rape Plant: Its History, Culture, and Uses; No. 14. Fertilizers for Cotton; No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them; No. 16. Leguminous Plants for Green Manuring and for Feeding; No. 17. Peach Yellows and Peach Rosette; No. 18. Forage Plants for the South; No. 19. Important Insecticides: Directions for their Preparation and Use; No. 20. Washed Soils: How to Prevent and Reclaim Them; No. 21. Barnyard Manure; No. 22. Feeding Farm Animals; No. 23. Foods: Nutritive Value and Cost; No. 24. Hog Cholera and Swine Plague; No. 25. Peanuts: Culture and Uses; No. 26. Sweet Potatoes: Culture and Uses; No. 27. Flax for Seed and Fiber; No. 28. Weeds, and How to Kill Them; No. 29. Souring of Milk and Other Changes in Milk Products; No. 30. Grape Diseases on the Pacific Coast; No. 31. Alfalfa, or Lucern; No. 32. Silos and Silage; No. 33. Peach Growing for Market; No. 34. Meats: Composition and Cooking; No. 35. Potato Culture; No. 36. Cotton Seed and Its Products; No. 37. Kafir Corn: Characteristics, Culture, and Uses; No. 38. Spraying for Fruit Diseases; No. 39. Onion Culture; No. 40. Farm Drainage.

The Department has no list to whom all publications are sent. The Monthly List of Publications, issued the 1st of each month, will be mailed to all who apply for it. In it the titles of the publications are given, with a note explanatory of the character of each, thus enabling the reader to make intelligent application for such bulletins and reports as are certain to be of interest to him.

For the maps and bulletins of the Weather Bureau, requests and remittances should be directed to the Chief of that Bureau. For all publications to which a price is affixed, application must be made to the Superintendent of Documents, Union Building, Washington, D. C., accompanied by the price thereof, and all remittances should be made to him and not to the Department of Agriculture, and such remittances should be made by postal money order and not by private check or postage stamps.

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PUBLICATIONS OF THE YEAR.

The following publications were issued by the U. S. Department of Agriculture during the fiscal year ended June 30, 1895:

OFFICE OF THE SECRETARY.

	Copies.
Suggestions Regarding the Cooking of Food. By Edward Atkinson. With Introductory Statements Regarding the Nutritive Value of Common Food Materials. By Mrs. Ellen H. Richards. Pp. 31, figs. 3. August, 1894	10,000
Special Report of the Assistant Secretary of Agriculture for 1893. By Edwin Willits. Pp. iv, 53-86. (From the Annual Report of the Secretary of Agriculture.) August, 1894	100
Report of the Secretary of Agriculture for 1893. Pp. 608, pls. 29, figs. 7. October, 1894	500,000
Report of the Secretary of Agriculture for 1894. Preliminary. Pp. 75, fig. 1. November, 1894. (Including reprint.)	20,000
Washed Soils: *How to Prevent and Reclaim Them.* Pp. 22, figs. 6. Farmers' Bulletin, No. 20. November, 1894. (Including reprint.)	68,000
Supplement to the General Index of the Agricultural Reports for the Years 1877 to 1885, Inclusive. Pp. 113. March, 1895. (Reprint.)	200
A General Index to the Agricultural Reports of the Patent Office for Twenty-five Years, from 1837 to 1876. Pp. 225. April, 1895. (Reprint.)	200
The World's Markets for American Products.—Great Britain and Ireland. Pp. 93, fig. 1. Bulletin No. 1, Section of Foreign Markets. May, 1895	10,000
Report of the Secretary of Agriculture; being part of the Messages and Documents Communicated to the Two Houses of Congress at the Beginning of the Third Session of the Fifty-third Congress. Pp. 220, figs. 2. May, 1885	3,000
Peaches and Other Fruits in England. Pp. 4. Circular No. 1, Section of Foreign Markets. June, 1895	10,000
The World's Markets for American Products.—The German Empire. Pp. 91, pl. 1. Bulletin No. 2, Section of Foreign Markets. June, 1895	10,000
Report of the Special Agent for the Purchase of Seeds for 1894. By Enos S. Harnden. Pp. iii, 211-213. (From the Annual Report of the Secretary of Agriculture.) March, 1895	500

DIVISION OF ACCOUNTS AND DISBURSING OFFICE.

Report of the Chief of the Division of Accounts and Disbursements foi 1893. By F. L. Evans. Pp. iii, 411-415. (From the Annual Report of the Secretary of Agriculture.) August, 1894	100
Report of the Chief of the Division of Accounts and Disbursements for 1894. By F. L. Evans. Pp. iii, 189-194. (From the Annual Report of the Secretary of Agriculture.) March, 1895	500

BUREAU OF ANIMAL INDUSTRY.

Additional Investigations Concerning Infectious Swine Diseases. By Theobald Smith, Ph. B., M. D., and Veranus A. Moore, B. S., M. D. Pp. 117. Bulletin No. 6. July, 1894	3,000
Report of the Chief of the Bureau of Animal Industry for 1893. By D. E. Salmon. Pp. iii, 123-168. (From the Report of the Secretary of Agriculture.) August, 1894	100
Wheat as a Food for Growing and Fattening Animals. By D. E. Salmon, D. V. M. Pp. 4. Circular of Information No. 2. August, 1894. (Including reprints.)	25,000
Investigations Concerning Bovine Tuberculosis, with Special Reference to Diagnosis and Prevention. Conducted under the direction of Dr. D. E. Salmon, Chief of the Bureau of Animal Industry. Pp. 178, pls. 6. October, 1894	5,000

	Copies.
Hog Cholera and Swine Plague. By D. E. Salmon, D. V. M., Chief of the Bureau of Animal Industry. Pp. 16. Farmers' Bulletin No. 24. December, 1894. (Including reprints.)	90,000
Regulations for the Inspection of Live Stock and their Products. Pp. 8. Circular. June, 1895	2,000

DIVISION OF BOTANY.

Report of the Botanist for 1893. By Frederick V. Coville. Pp. iii, 235–244. (From the Annual Report of the Secretary of Agriculture.) August, 1894	2,100
Nut Grass. Pp. 4, fig. 1. Circular No. 2. October, 1894	5,000
The Russian Thistle. Pp. 8, figs. 3. Circular No. 3. January, 1895	10,000
Contributions from the United States National Herbarium, Vol. I, No. 9. Report on a collection of plants made in the States of Sonora and Colima, Mexico, by Dr. Edward Palmer, in the years 1890 and 1891. By J. N. Rose, Assistant Botanist. Pp. v, 293–434, viii, frontispiece, pls. 24–35, figs. 10. January, 1895	2,500
American Ginseng: Its Commercial History, Protection, and Cultivation. Pp. 22, figs. 2. By George V. Nash. Bulletin No. 16. February, 1895	3,000
The Flat Pea. Pp. 7, figs. 2. Circular No. 4. March, 1895	3,000
Giant Knotweed, or Sachaline. Pp. 4, figs. 3. Circular No. 5. March, 1895	3,000
Weeds; and How to Kill Them. Lyster H. Dewey, Assistant Botanist. Pp. 31, figs. 11. Farmers' Bulletin No. 28. May, 1895	20,000
Report of the Botanist for 1894. By Frederick V. Coville. Pp. iii, 161–166. (From the Annual Report of the Secretary of Agriculture.) May, 1895	500

GARDENS AND GROUNDS.

Papers on Horticultural and Kindred Subjects. By William Saunders, Horticulturist and Landscape Gardener, Superintendent of Gardens and Grounds. Pp. 124. November, 1894. (Reprint.)	5,000

OFFICE OF EXPERIMENT STATIONS.

Forage Plants for the South. By S. M. Tracy, M. S., Director of the Mississippi Agricultural Experiment Station. Pp. 30, figs. 17. Farmers' Bulletin No. 18. August, 1894. (Including reprint.)	70,000
Proceedings of the Seventh Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, held at Chicago, Ill., October 17–19, 1893. Pp. 100. Bulletin No. 20. August, 1894	4,000
Report of the Director of the Office of Experiment Stations for 1893. By A. C. True. Pp. iv, 417–464. (From the Annual Report of the Secretary of Agriculture.) August, 1894	1,100
Handbook of Experiment Station Work. A Popular Digest of the Publications of the Agricultural Experiment Stations in the United States. Prepared by the Office of Experiment Stations. Pp. 411. Bulletin No. 15. November, 1894. (Reprint.)	3,000
Barnyard Manure. By W. H. Beal, of the Office of Experiment Stations. Pp. 32, figs. 7. Farmers' Bulletin No. 21. November, 1894. (Including reprints.)	165,000
Milk Fermentations and Their Relations to Dairying. Prepared in the Office of Experiment Stations from Bulletin No. 9. Pp. 24. Farmers' Bulletin No. 29. January, 1895. (Including reprints.)	35,000
Foods: Nutritive Value and Cost. By W. O. Atwater, Ph. D., Professor of Chemistry in Wesleyan University. Pp. 32, charts 2. Farmers' Bulletin No. 23. January, 1895. (Including reprint.)	65,000
Tobacco: Instructions for its Cultivation and Curing. By John M. Estes, Special Agent. Pp. 8. Farmers' Bulletin No. 6. February, 1895. (Including reprints.)	53,000
The Feeding of Farm Animals. By E. W. Allen, Ph. D., Assistant Director of the Office of Experiment Stations. Pp. 32. Farmers' Bulletin No. 22. February, 1895. (Including reprints.)	150,000
Peanuts: Culture and Uses. By R. B. Handy, of the Office of Experiment Stations. Pp. 24, fig. 1. Farmers' Bulletin No. 25. February, 1895. (Including reprints.)	46,000

	Copies.
Fertilizers for Cotton. By J. M. McBryde, Ph. D., President of Virginia Agricultural and Mechanical College and Director of Virginia Agricultural Experiment Station. Pp. 31. Farmers' Bulletin No. 14. February, 1895. (Including reprints.)	25,000
A Compilation of Analyses of American Feeding Stuffs. By E. H. Jenkins, Ph. D., and A. L. Winton, Ph. B. Pp. 155. Bulletin No. 11. February, 1895. (Reprint.)	1,000
Leguminous Plants for Green Manuring and for Feeding. By E. W. Allen, Ph. D., Assistant Director of the Office of Experiment Stations. Pp. 24. Farmers' Bulletin No. 16. March, 1895. (Including reprints.)	55,000
The Rape Plant: Its History, Culture, and Uses. By Thomas Shaw, Professor of Agriculture in the Ontario Agricultural College. Pp. 20, figs. 4. Farmers' Bulletin No. 11. March, 1895. (Including reprints.)	15,000
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Report of the Director of the Office of Experiment Stations for 1894. By A. C. True. Pp. iii, 123–131. (From the Annual Report of the Secretary of Agriculture.) April, 1895	1,000
Organization Lists of the Agricultural Experiment Stations and Institutions with Courses in Agriculture in the United States. Pp. 88. Bulletin No. 23. May, 1895	3,000
Methods and Results of Investigations on the Chemistry and Economy of Food. By W. O. Atwater, Ph. D., Professor of Chemistry in Wesleyan University, Director of the Storrs (Conn.) Agricultural Experiment Station, and Special Agent of the United States Department of Agriculture. Pp. 222, figs. 15, charts 3. Bulletin No. 21. May, 1895	3,000
Statistics of Agricultural Colleges and Experiment Stations, 1894. Pp. 18. Circular No. 27. June, 1895	5,000
Experiment Station Record. (A condensed record of the contents of the bulletins and reports issued by the Agricultural Experiment Stations of the United States, and also a brief review of agricultural science of the world.)	
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DIVISION OF CHEMISTRY.

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Report on the Extent and Character of Food and Drug Adulteration. By Alex. J. Wedderburn, Special Agent. Published by order of Congress. Pp. 64. Bulletin No. 41. October, 1894	2,500
A Compilation of the Pharmacy and Drug Laws of the Several States and Territories. By Alex. J. Wedderburn, Special Agent. Published by order of Congress. Pp. 152. Bulletin No. 42. November, 1894	2,500
Proceedings of the Eleventh Annual Convention of the Association of Official Agricultural Chemists, held at Washington, D. C., August 23, 24, and 25, 1894. Edited by Harvey W. Wiley, Secretary of the Association. Pp. 403. Bulletin No. 43. December, 1894	3,500
Experiments with Sugar Beets in 1892. By Harvey W. Wiley, Chief Chemist of the United States Department of Agriculture and Director of the Department Sugar Experiment Stations at Schuyler, Nebraska;	

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Runnymede (Narcoossee P. O.), Florida, and Sterling and Medicine Lodge, Kansas. With the collaboration of Dr. Walter Maxwell, Assistant in charge of the Schuyler Station. Pp. 74. Bulletin No. 36. December, 1894. (Reprint.)	500
Experiments with Sugar Beets in 1890. By Harvey W. Wiley, Chief Chemist of the United States Department of Agriculture and Director of the Department Sugar Stations at Schuyler, Nebraska; Runnymede (Narcoossee P. O.), Florida, and Sterling and Medicine Lodge, Kansas. Pp. 93. Bulletin No. 30. December, 1894. (Reprint.)	500
Proceedings of the Ninth Annual Convention of the Association of Official Agricultural Chemists, held at the National Museum, Washington, D. C., August 25, 26, and 27, 1892. Edited by Harvey W. Wiley, Secretary of the Association. Pp. v, 243, xvii. Bulletin No. 35. December, 1894. (Reprint.)	500
Proceedings of the Seventh Annual Convention of the Association of Official Agricultural Chemists, held at the United States National Museum, August 28, 29, and 30, 1890. Methods of Analysis of Commercial Fertilizers, Foods and Feeding Stuffs, Dairy Products, Fermented Liquors and Sugars. Edited by Harvey W. Wiley, Secretary of the Association. Pp. 238, figs. 21. Bulletin No. 28. December, 1894. (Reprint.)	500
Experiments with Sugar Beets in 1893. By Harvey W. Wiley, Chemist of the United States Department of Agriculture and Director of the Department Sugar Experiment Stations at Schuyler, Nebraska; Runnymede (Narcoossee P. O.), Florida, and Sterling and Medicine Lodge, Kansas. With the collaboration of Dr. Walter Maxwell, Assistant in charge of the Schuyler Station. Pp. 59. Bulletin No. 39. December, 1894. (Reprint.)	500
Foods and Food Adulterants. Fermented Alcoholic Beverages, Malt Liquors, Wines, and Cider. By C. A. Crampton, Assistant Chemist. Pp. 261–399, figs. 2. Bulletin No. 13, Part III. December, 1894. (Reprint.)	500
Sweet Cassava: Its Culture, Properties, and Uses. By Harvey W. Wiley, Chemist of the United States Department of Agriculture. Pp. 16, pls. 2, fig. 1. Bulletin No. 44. January, 1895	5,000
The Sugar Beet Industry. Culture of the Sugar Beet and Manufacture of Beet Sugar. By H. W. Wiley, Chemist. Pp. 262, pls. 11, figs. 49. Bulletin No. 27. January, 1895. (Reprint.)	500
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Record of Experiments with Sorghum in 1892. By Harvey W. Wiley, Chemist of the United States Department of Agriculture and Director of the Department Sugar Experiment Stations at Schuyler, Nebraska; Runnymede (Narcoossee P. O.), Florida, and Sterling and Medicine Lodge, Kansas. With the collaboration of Messrs. A. A. Denton, Glen O'Brien, C. I. Hinman, Wibray J. Thompson, J. L. Fuelling, and Oma Carr. Pp. 100. Bulletin No. 37. February, 1895. (Reprint.)	500
Foods and Food Adulterants. Spices and Condiments. By Clifford Richardson. Pp. ii, 129–259, pls. 13–28, figs. 5–13. Bulletin No. 13, Part II. February, 1895. (Reprint.)	500
Culture of the Sugar Beet. By H. W. Wiley, Chemist of the Department of Agriculture and Director of the Department Sugar Experiment Station in Nebraska. Pp. 24, figs. 9. Farmers' Bulletin No. 3. April, 1895. (Reprint.)	15,000

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The Army Worm (*Leucania unipuncta* How.) Pp. 5, figs. 3. Circular No. 4, second series. July, 1894	5,000
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Report on the Mexican Cotton-Boll Weevil in Texas (*Anthonomus grandis* Boh.). By C. H. Tyler Townsend, Temporary Field Agent. Pp. 295–309, from Insect Life, Vol. VII, No. 4. March, 1895	2,000
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DIVISION OF FORESTRY.

Report of the Chief of the Division of Forestry for 1893. By B. E. Fernow. Pp. iii, 303–364, pls. 3, figs. 4. (From the Annual Report of the Secretary of Agriculture.) October, 1894	10,100

	Copies.
Report on the Use of Metal Railroad Ties and on Preservative Processes and Metal Tie Plates for Wooden Ties. By E. E. Russell Tratman, A. M. Am. Soc. C. E. [Supplementary to Report on the Substitution of Metal for Wood in Railroad Ties, 1890.] Prepared under the direction of B. E. Fernow, Chief of the Division. Pp. 363, pls. 5. Bulletin No. 9. May, 1895	8,000

OFFICE OF FIBER INVESTIGATIONS.

A Report on the Uncultivated Bast Fibers of the United States, including the History of Previous Experiments with the Plants or Fibers, and Brief Statements Relating to the Allied Species that are Produced Commercially in the Old World. By Charles Richards Dodge, Special Agent. Pp. 54, pls. 5. Report No. 6. July, 1894	6,000
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Flax for Seed and Fiber in the United States. By Charles Richards Dodge, Special Agent for Fiber Investigations. Pp. 16. Farmers' Bulletin No. 27. March, 1895. (Including reprints.)	25,000

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DIVISION OF ORNITHOLOGY AND MAMMALOGY.

Report of the Ornithologist and Mammalogist for 1893. By C. Hart Merriam. Pp. iii, 227–234, pl. 1. (From the Annual Report of the Secretary of Agriculture.) October, 1894	600
North American Fauna No. 8. Monographic Revision of the Pocket Gophers, Family *Geomyidæ* (exclusive of the species Thomomys). By Dr. C. Hart Merriam. Pp. 258, frontispiece, pls. 19, maps 4, figs. 71. January, 1895	5,000
The Pocket Gophers of the United States. Prepared under the direction of Dr. C. Hart Merriam, Chief of Division, by Vernon Bailey, Chief Field Agent. Pp. 47, frontispiece, figs. 6, map 1. Bulletin No. 5. May, 1895	5,000

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Report of the Assistant Pomologist for 1893. By W. A. Taylor. Pp. iii, 277–296. (From the Annual Report of the Secretary of Agriculture.) September, 1894	10,200

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Report of the Chief of the Division of Records and Editing for 1893. By Geo. Wm. Hill. Pp. iii, 395–408. (From the Annual Report of the Secretary of Agriculture.) August, 1894	200
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Notes on the Employment of Convicts in Connection with Road Building. Compiled by Roy Stone, Special Agent and Engineer. Pp. 15. Bulletin No. 16. June, 1895	5,000

SEED DIVISION.

Report of the Chief of the Seed Division for 1893. By M. E. Fagan. Pp. iii, 389–392. (From the Annual Report of the Secretary of Agriculture.) August, 1894	500

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